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Report of

Panel on

Coastal Zone and University/National Laboratories,



Submitted to

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National Council

on

Marine Resources and Engineering Development.

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Report of
Panel on
Coastal Zone and University/National Laboratories

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Washington, D.C.

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Report Submitted to
National Council
on
Marine Resources and Engineering Development

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PREFACE

The Charter of the Panel on Coastal Zone and University/National Laboratories gave the Panel responsibility to

- Analyze the national requirements for marine research and training and the current capabilities to provide the information and personnel required to utilize more wisely and fully the marine environment.
- Evaluate those recommendations of the Commission on Marine Sciences, Engineering and Resources which apply to Coastal Zone laboratories and University/National laboratories.
- Develop possible alternatives to the Commission's recommendations and present the pros and cons of each.
- Recommend to the National Council on Marine Resources and Engineering Development a course of action.

The Panel reviewed the recommendations of the Commission on Marine Sciences, Engineering and Resources and determined that the following recommendations were directly relevant to its considerations.

- University/National laboratories should be established at appropriate locations, equipped with the facilities necessary to undertake global and regional programs in ocean science, and assured adequate institutional funding for continuity and maintenance of both programs and facilities.
- Coastal Zone laboratories should be established in association with appropriate academic institutions to engage in the scientific investigation of estuarine and coastal processes, and to be prepared to advise the States in managing the estuaries and coastal zones.
- The National Oceanic and Atmospheric Agency (National Sea Grant Program) should have the prime responsibility to provide institutional support for the Coastal Zone laboratories. The Sea Grant College and Program Act of 1966 should be amended to permit grants for the construction and maintenance of vessels and other facilities.
- Federal marine science laboratories should be strengthened by adequate funding and staffing. Selective consolidation of marginal laboratories is one way of achieving this purpose; however, it should be remembered that effectiveness is not necessarily a function of size.
- The National Science Foundation should expand its support for undergraduate and graduate education in the basic marine related scientific disciplines and plan post-doctoral and mid-career marine orientation programs in consultation with the academic and industrial marine communities.

- The National Oceanic and Atmospheric Agency should be assigned responsibility to help assure that the nation's marine manpower needs are satisfied and to help devise uniform standards for the nomenclature of occupations.
- The National Oceanic and Atmospheric Agency should expand its support of ocean engineering and marine technician training at all levels and should aid selected universities in organizing graduate-level education in the application of social sciences to marine affairs.

In addition to the recommendations put forth by the Commission, each of the individual Panels made many recommendations. In particular, the Panel on Basic Science and Research made the following recommendations:

- The present variety of institutional arrangements for the development and support of oceanography is good and should be nurtured. Furthermore, as the horizons of oceanography continue to expand, new institutional arrangements can be encouraged.
- A small group of institutions, which should include but should not be restricted to the acknowledged leaders, should be designated "University/National laboratories." They should be distributed geographically to cover different parts of the oceans and should be provided with adequate facilities for undertaking global, deep-ocean programs and basic science. Facilities should be made available to scientists at other universities and federal laboratories for related basic-science activity. University/National laboratories should be accorded adequate institutional support for maintenance and operation, and in turn they should commit themselves and their facilities to serve the needs of scientific groups affiliated with other institutions. Such an institutional arrangement will insure that the nation's leading oceanographic institutions will be provided adequate resources and support to insure their continued health and vigor.
- A network of estuarine and coastal-zone research institutions should be established in association with appropriate academic institutions to undertake the basic and applied research on estuarine processes so that state and local governments can have information on which to base management procedures rationally. These facilities need not be large in size, but should have adequate facilities and staff sizes exceeding the critical limit to maintain stable programs. The activity should be supported under the Sea Grant Program.
- Federal laboratories should be strengthened by moving in the direction of fewer but stronger laboratories, adequately staffed, and with even closer affiliations with academic institutions. Steps should be taken to provide an atmosphere in these laboratories conducive to attracting first-rank scientists by providing the necessary flexibility at the scientific leadership level.

In response to its assignment, the Panel has reviewed a number of actions which might be followed to implement these recommendations. A number of alternative concepts are presented herein relative to possible Federal positions with respect to University/National laboratories and to Coastal Zone laboratories. It is believed that all of the presently recognized advantages and disadvantages of each of the possible options have been set down. In addition, the Panel has presented a general discussion of administrative factors and policy decisions that must be considered before any of the recommendations are implemented.

Any course of action that the Federal government elects to pursue will have inherent advantages and disadvantages. No uniquely excellent course of action exists for the implementation of the recommendations in the Commission's report.

The Panel's conclusions are presented with full recognition of the difficulties which may be encountered. These choices were based on considerations which were believed would result ultimately in the greatest long-term national strength in marine activities.

PANEL FINDINGS AND RECOMMENDATIONS

COASTAL ZONE LABORATORIES

The position of the United States Government with respect to Coastal Zone laboratories should be guided by the needs and objectives of the Nation in the maintenance, restoration, and proper use of the coastal zone. These needs and objectives include:

- The development of a value system for determining, in the best public interest, a proper mix of tangible vs intangible, social vs economic, and consumptive vs nonconsumptive uses.
- The prevention and abatement of environment deterioration.
- The resolution of conflicting valid uses (e.g., public access vs private ownership, fish and wildlife vs landfill, industrial development vs preservation of natural areas, and water quality vs waste-disposal requirements).
- The development of knowledge to predict the consequences of man-made changes in the environment and estuarine habitats.
- The development of knowledge to determine optimum planning for mineral extraction, aquaculture, and fish husbandry.
- The assessment of economic, social, legal, and policy interactions in the best long-term public interest.
- The minimizing of damage from natural events — e.g., storms, tsunamis, and currents — while maintaining the environment.
- The development of long- and short-range plans, based on comprehensive and continuously evolving models of the coastal zone, which give appropriate recognition to all relevant scientific, economic, legal, and social considerations.

These needs exist at Federal, State, and local levels. Each has responsibilities related to the coastal zone. The Panel believes that the best way to provide the analysis, research, and development needed for a rational approach to the proper management and utilization of the coastal zone would be to establish and designate multidisciplinary laboratories with area and regional interests.

While most research, development, and analysis must be directed to regional and local coastal-zone components, there are clear national requirements which have been imposed on agencies of the Federal government. Consequently, the Panel believes that, to fulfill the national needs in the coastal zone, laboratories must be maintained both by the Federal government and by institutions capable of meeting regional and local needs. The Panel proposes to distinguish between the two types of laboratories with the names, Federal Area Coastal Zone Laboratory and Regional Coastal Zone Laboratory.

Federal Area Coastal Zone Laboratories, operated by a department of the Federal government, would represent Federal responsibilities and agency missions, such as those of the Bureau of Commercial Fisheries, the Federal Water Pollution Control Administration, the Environmental Science Services Administration, the U.S. Public Health Service, the U.S. Bureau of Mines, the U.S. Geological Survey, the Bureau of Sport Fisheries and Wildlife, the National Park Service, and the Atomic Energy Commission. The FACZL's would conduct research necessary to the implementation of Federal missions, and in addition could provide certain facilities for common use in the areas they serve.

Regional Coastal Zone Laboratories would conduct research, analysis, and development specifically related to the coastal zones of their region, and would serve as scientific and technical advisors to Coastal Zone Authorities and appropriate State agencies.

The Panel has arrived at this division of responsibility for Coastal Zone laboratories in the belief that, if implemented, establishment of Federal Area Coastal Zone Laboratories and Regional Coastal Zone Laboratories would:

- Demonstrate the Federal government's recognition of the clear interests of the State governments in many matters relating to coastal-zone management, and its recognition that it is in the interest of the National well being that appropriate State authorities have as much technically competent judgment as possible on which to base their decisions.
- Create technical organizations to give adequate research and technological support to the Federal decision-making process as it relates to coastal-zone matters.
- Recognize through Federal action the need to support Regional Coastal Zone Laboratories which can conduct a vigorous research program, develop the technology for the effective utilization of the coastal zone, and assume responsibilities for training the necessary scientists, engineers, and technicians.

The Panel has considered a number of options which might be pursued in order to implement the foregoing. These options, together with possible advantages and disadvantages, are delineated in Section II of Chapter 1 of the text of this report.

The Panel has considered these options and has made the choices outlined in the following pages. Whichever option is ultimately selected by the Federal government, the Panel believes that it is imperative to implement the following specific recommendation.

The organization of Coastal Zone laboratories should be based on major coastal zone areas, which are in turn composed of regions based on considerations of ecology, commonality of problems, and geographical factors. The coast of the United States should be considered in terms of 10 major areas and 27 regions, defined in section I.D.2 of Chapter 1 of the text of this Report.

Based on either experience or the changing interests of these areas, the details of the area and regional boundaries may be subject to some alteration.

The Panel, which concurs in principle with the sense of urgency and organizational recommendations of the Commission on Marine Science, Engineering, and Resources, makes the following specific recommendations with respect to Federal Area Coastal Zone Laboratories.

- To support its own statutory responsibilities, the Federal government should organize and operate a multidisciplinary Coastal Zone laboratory in each coastal area.
- The initial nucleus for these laboratories should come from a consolidation by the Department of Interior of the laboratories of its several bureaus. In a later stage, the broader needs of the Federal government should be met by collocating other Federal laboratories with those of the Department of the Interior.
- In the event that a National Oceanic and Atmospheric Agency (NOAA) is created, along the lines recommended in the Commission's report, then it would seem necessary and proper to assign these area Coastal Zone Laboratories to NOAA.

With respect to Regional Coastal Zone Laboratories, the Panel recommends that:

- Based on proposals received and accepted, Regional Coastal Zone Laboratories for each of the 27 regional subdivisions should be designated, no later than 1975. This action should not prejudice, as experience and need may warrant, future subdivisions of the initially selected regions.
- Each of these Regional Coastal Zone Laboratories should be under the auspices of institutions of higher education or affiliated organizations with competence in coastal zone research. The research activities should be augmented, as appropriate, by consortium arrangements with other public and private institutions.
- The total competence involved should include the several scientific disciplines and engineering specialties, the law, economics, sociology, and such other specialties as may be necessary for proper analysis and research into coastal zone problems and opportunities by consortia and other arrangements.
- Federal responsibility for designation and core support of Regional Coastal Zone Laboratories should be assigned to the National Science Foundation,

which should review and recommend any changes in legislation required to carry out this responsibility.

- Other Federal agencies with mission interests in the coastal zone should cooperate actively with the Regional Coastal Zone Laboratories and should fund as necessary, by direct grant or contract, research appropriate to their mission interests, consulting with NSF to insure a coordinated program. The Regional Coastal Zone Laboratories should be established on a cost-sharing basis.
- The cognizant Federal agency should develop a cost-sharing formula to determine the percentages to be provided from Federal and non-Federal sources for the construction of facilities and operations.
- The cognizant Federal agency will provide mechanisms for a comprehensive periodic review to insure that the research programs of both the Area and Regional Coastal Zone Laboratories are responsive to the needs of their areas and regions and their sponsors.

The Panel suggests that the process for selection and designation should require "candidate" Regional Coastal Zone Laboratories to provide:

1. A description of existing facilities that are available through the lead institution or through consortium members, if any.
2. A projection of additional facilities needed to accomplish the research program, together with cost estimates.
3. Budget plans for a 5-year program, shown in annual increments.
4. The proposed composition and organizational affiliations of laboratory advisory groups which will be established.
5. A plan detailing the nature and method of interaction with cognizant State or Regional Coastal Zone Authorities and the general public.
6. A plan for facilities for the education and training of personnel competent in coastal-zone problems.

The Panel notes that there is no Federal agency with an assigned responsibility for delineating and monitoring coastal zone problems and opportunities. The Panel therefore recommends that:

- The Department of the Interior should establish a program for the compilation and analysis of information relating to the total national interest in the coastal zone, and for recommendation to the President of appropriate policy and program development as such compilation and analysis may indicate.

UNIVERSITY/NATIONAL LABORATORIES

The Panel has reviewed the Commission's recommendations relative to the creation of University/National laboratories. We believe that the policy of the Federal government should be oriented towards an enhanced understanding of the global sea. To achieve this objective at an accelerated pace, specific goals of the Nation should be directed towards:

- Encouraging exploratory research and development in marine science and engineering.
- Supplying an environment in which new ideas may be conceived, supported in their infancy, and developed into working models.
- Maintaining an effective national position for advancing and working cooperatively in the international aspects of marine science and technology.
- Assuring that the marine manpower needs of the United States are met by providing graduate, postdoctoral, and continuing education for marine scientists and engineers.
- Assuring that marine engineering and technology are based on good science, and that sound engineering and technological support are used in the advancement of marine science.
- Encouraging and fostering long-term, large-scale scientific and technological programs and providing the management of facilities for their accomplishment.

Since the phrase "University/National Laboratory" was not explicitly defined in the Commission's report, the Panel has adopted the following definition.

A University/National Laboratory is a largely Federally funded laboratory complex whose major responsibility is to carry out research and development oriented towards goals of national importance. It further has the duty of designing, operating and providing to the American scientific community unique and/or expensive facilities for carrying out oceanic research. In addition, it is a center where basic and applied research and exploratory development can be carried out on a continuing basis using a multidisciplinary approach.

The Panel suggests that the name National Oceanographic Laboratory be used as a substitute for the name University/National Laboratory.

In reviewing the Commission's recommendations and various alternate options which might be adopted, the Panel has been guided by the following considerations:

- Major aspects of our understanding and utilization of the world ocean will depend increasingly on the types of studies most effectively carried out at large, multidisciplinary laboratories.
- Studies of great national importance will require additional special facilities, including ships, exotic platforms, aircraft, buoys, submersibles, and man-in-the-sea equipment and habitats.
- A sizable number of existing institutions, with demonstrated competence in oceanic studies, can provide the proper base on which to build national efforts of expanded scope.
- The high cost of procuring and operating major facilities and equipment increasingly will require provision for common and efficient usage by the oceanographic research community at large.

The following four main options, which are not necessarily mutually exclusive, have been considered by the Panel:

Option 1

The U.S. Government could designate one or more existing oceanographic laboratories as National Oceanographic Laboratories. Overhead, support, and facilities costs, as well as sufficient funding to enable these laboratories to grow to some preassigned size, would be provided by the Federal government.

Option 2

The U.S. Government could "nationalize" the use of all oceanographic facilities for which it now provides predominant budgetary support. These facilities (predominantly ships) would be maintained, supported, and expanded by a single Federal agency, and the services of these facilities would be made available to all competent oceanographers.

Option 3

The U.S. Government could encourage strongly the formation of regional laboratory consortia, which would be composed of all the oceanographic laboratories in a given geographic region of the country. Consortium facilities of a unique nature would be provided by the Federal government, and the consortium members would be expected to use these facilities jointly.

Option 4

The U.S. Government could accept present institutional forms, without sponsoring changes, and would encourage the growth of oceanographic research and training by increasing the magnitude of funding, and by instituting the block funding of facilities, support and overhead costs.

Details of these options, together with possible advantages and disadvantages of each option, are delineated in Section II of Chapter 2 of this report. The Panel has debated these options and their possible consequences quite extensively. With a clear recognition of these consequences, the Panel recommends a program that combines elements of Options 1, 3, and 4. Since funding is such an important consideration, the Panel strongly endorses the following admonition:

The Federal government should not establish a policy of giving selective growth and funding to National Oceanographic Laboratories unless the national oceanographic budget will permit both the continued growth of existing university and private laboratories and the simultaneous development of strong National Oceanographic Laboratories.

Failure to heed this admonition would have a catastrophic effect on the health of American oceanography, and would amount to disregarding the Commission's injunction that "the present variety of institutional arrangements for the development and support of oceanography is good and should be nurtured."

On the basis of the above admonition and findings, the Panel recommends that:

- Initially the United States Government should designate one major east coast oceanographic laboratory and one major west coast oceanographic laboratory as "National Oceanographic Laboratories." The Federal government should selectively sponsor the growth of these laboratories to that of a four- to five-hundred-man professional staff, together with the required support personnel.
- The United States Government should encourage and assist in the formation of regional oceanographic consortia of all of the oceanographic laboratories in a given geographic region of the country. Unique facilities should be provided to the consortia members. Strong encouragement should be given to the joint use of these facilities and to the establishment of cooperative research programs.
- An improved program should be established for the increased support of leading universities and private research institutions now engaged in oceanographic research and graduate training.

To implement these recommendations, the following general steps and procedures should be adopted.

- One Federal agency should be assigned the funding responsibility for all institutional support. This support should be block funded on the basis of negotiations following periodic institutional review.
- This Federal agency should also be given the major funding responsibility for the provision of ship and shore facilities.

- Sufficient funding should be provided to assure that existing oceanographic institutions are sustained at their present levels of operation and are permitted to grow at a rate commensurate with their capabilities and performance.

With regard to the designation and administration of the National Oceanographic Laboratory Program, the following guidelines are suggested.

- Candidate oceanographic institutions should be selected on the basis of demonstrated strength in broadly based oceanographic research as manifested by scientific accomplishments and by the research and facilities management skills at the institution.
- The institutions designated as National Oceanographic Laboratories must be willing to assume leadership and place proper emphasis on research and development programs oriented towards the achievement of broad national oceanic goals.
- An important consideration must be the willingness and ability of the institution to make appropriate formal arrangements for use of facilities by outside investigators and for cooperation with other institutions engaged in oceanic studies. It is anticipated that appropriate user committees will be established to govern the utilization and scheduling of facilities, and that membership in such committees would be open to State, private, and Federal institutions without geographic limitations.
- Funding for core operating expenses and facilities, and projects as appropriate, at the National Oceanographic Laboratory would be provided through the responsible Federal agency with administrative emphasis on maintaining continuity and local flexibility needed for effective scientific work.
- Additional support of projects at National Oceanographic Laboratories by State and private sources will be encouraged, as will support by all Federal sources.

The National Oceanographic Laboratory Program should be implemented through the following steps:

- Designation of the responsible agency by Executive Order.
- Formulation of program plans by the responsible agency based, in part, on discussions with appropriate oceanographic institutions.
- Selection of the two laboratories and the awarding of initial grants, preferably in FY 1971, to cover planning, travel, and other administrative costs associated with the development of a five-year plan for the two National Oceanographic Laboratories, including detailed consideration of proposed capital and operating costs.
- Review of the initial plan under the leadership of the responsible agency with representatives of other Federal agencies and other institutions with oceanographic interests.
- Inclusion of a National Oceanographic Laboratories Program in the proposed budget of the responsible agency as soon as feasible, preferably in FY 1972.

With regard to encouraging the development of regional consortia, the following procedures should be followed:

- Unique or expensive facilities, such as large computers, deep submergence vehicles, undersea habitats, large arrays of buoys, etc., should be located at or should be under the administration of one or another member laboratory of each consortium. These facilities would be available to competent scientists, as agreed upon by members of the consortium.
- User committees composed of scientists from the individual laboratories should be established for the equitable and efficient coordination and utilization of unique facilities and cooperative use of vessels as appropriate.
- The research programs of the individual laboratories should be locally controlled and administered, but cooperative research programs should be encouraged.
- Multiple-source funding of mission-oriented research should be continued and administered by the cognizant Federal agencies.
- Provisions should be made for the allocation of a block of funds for the support of promising research by students and recent graduates who have been selected by an appropriate consortium committee.
- A well-defined review procedure for member laboratories of each consortium should be developed and agreed upon by all parties concerned. The general procedures discussed in Section I.E.3. of Chapter 2 of the text of this report should be followed.

With regard to an improved program for the support of leading universities and private nonprofit research institutions now engaged in oceanographic research and training, the following guidelines are suggested:

- Funding should be provided to upgrade by replacement the fleet of research vessels which this group of institutions now operates. Priorities for replacements would be based on evaluation of program needs and the condition of vessels to be replaced.
- Funding should be provided for upgrading shore facilities, support for which has lagged in recent years.
- Block funding of ship operations should be provided by a single agency in order to increase efficiency of management, scheduling, and operation.
- Other institutional support should be provided for computing, shop, and other shared facilities and equipment and for a reasonable portion of supporting personnel; and general purpose research and training activities.

CONCLUSIONS RELATED TO MANPOWER REQUIREMENTS FOR THE MARINE SCIENCES

In response to its basic Charter, the Panel analyzed the national population employed in ocean-related fields. The analysis was carried out in terms of discipline orientations and levels of education. In addition, the current national ability to educate personnel in the various oceanographic disciplines was evaluated in the context of various projected growth rates and attrition factors. The Panel finds that:

- If it is assumed that there will be an annual five-percent attrition of people already in the field and an overall annual growth rate of three percent, then a net annual rate of production of graduate oceanographers in the physical and biological disciplines would exceed the yearly requirements for these fields.
- A majority of personnel employed in one of the physical science sub-disciplines of oceanography are not oceanographers. They tend to have been educated specifically as physicists, chemists, meteorologists, etc. Consequently, a large fraction of the physical scientists engaged in marine research and development could, in the future, continue to be staffed in part by personnel recruited from the total population of graduates from the physical-science departments of American universities.
- Although there is an adequate supply of graduates in the physical and biological sciences engaged in marine activities, deficiencies could occur in subdisciplinary specialties.
- Since ocean engineering is a relatively new field of graduate-level education, few personnel with expertise in the design and construction of marine structures are available. Thus, some difficulty may be encountered if a growth in applied marine engineering and advanced technology were to be sustained only by the present ocean-engineering manpower pool and rate of production.
- Technician requirements parallel those for engineers. The short-term, less intensive training required for technicians suggests that the supply of marine technicians could adjust more readily to specific demands through recruitment and on-the-job training and existing educational programs than the supply of more highly trained personnel.

Having assessed the current and anticipated national involvement in the marine sciences, the Panel accepted the following conclusions with regard to ocean manpower requirements.

- The present production rate of graduate oceanographers and other marine scientists is adequate for the current level of national involvement in ocean science and technology.
- The current training rate of ocean scientists appears adequate to match attrition and turnover losses of five percent and to sustain a net annual growth rate of three percent. A greater rate of annual increase in applied marine programs would require a modest increase in the current training rate of graduate ocean engineers and scientists. The required increase could be easily achieved by a small expansion of existing university programs.

- Certain specialized areas of marine research are undermanned relative to national needs. The number of disciplines and the personnel requirements in this category are sufficiently small that the deficiencies can be easily rectified through existing programs.

FEDERAL LABORATORIES

In evaluating the Commission's recommendations and in developing possible alternatives, the Panel kept firmly in mind the following admonition of the Commission:

"The role of the Federal Laboratory is critical not only to the missions of the Federal agencies, but to the entire national marine sciences enterprise."

The Panel paid particular attention to both defense and nondefense Federal marine laboratories. Both classes of laboratories were carefully considered in the many Panel discussions. The present and potential roles of all Federal laboratories were debated in the analyses of alternative options for both Coastal Zone and University/National laboratories.

A summary of these laboratories is contained in Chapter 4 of this report. Sections II of Chapters 1 and 2 document the various options, together with the possible advantages and disadvantages of Federal laboratories, relative to the alternatives developed by the Panel in its deliberations on Coastal Zone and University/National laboratories.

As a result of its review, the Panel finds that:

- The term "Federal laboratory," as used in the Commission's Report, actually encompasses a heterogeneous grouping of over 80 mission-oriented laboratories, large and small, which vary in size from some 10 scientists and support personnel at the Bureau of Sport Fisheries and Wildlife Tiburon Marine Laboratory, Tiburon, California, to over 3500 professional and support personnel who make up the Naval Ship Research and Development Center, Carderock, Maryland.
- By organization, these Federal marine laboratories report to 29 bureaus of 11 departments and agencies of the Federal government. By mission, they support the authorities and responsibilities of their superior agencies who collectively are charged with the responsibility for deriving the maximum benefit to the United States economy, security, health, and welfare from marine-science activities. In management, most share such common ills of Federal agencies as excessive layers of superior organizations and lack of control in balancing the resources of men, money, and materials against assigned workload. Quantitatively, there are some 85 Federal marine laboratories. Qualitatively, the Commission's report noted that "some of them are understaffed and underutilized, some involved in research somewhat removed from their agency's primary interests, but most with programs of high quality. These laboratories form a valuable component of the national capability in marine science."
- As evidenced by their recommendations for selective consolidation of marginal laboratories into a small number of stronger centers, the Commission clearly favored fewer, stronger, and more adequately staffed

and equipped Federal laboratories. While the Commission was indefinite as to which laboratories they judged to be "marginal," it is apparent that the Commission was principally concerned with the ability of the many small nondefense Federal laboratories to support the statutory responsibilities of their parent agencies.

- There is an immediate need for well-rounded, well-equipped, and well-staffed Federal research centers which have the organic capability to employ a systematic approach to the conduct of research primarily related to the missions of their parent agencies. It is noted that there is no universally accepted standard for the critical or optimum size of a Federal or any other type of laboratory. The situation is further complicated in the area of estuarine and coastal-zone research where, because of the highly local nature of the problems, it may be best not to coalesce all small laboratories within a given regional area into one center.
- In keeping with the broad responsibilities of the Federal government in coastal affairs, it is highly preferable to employ the appropriate non-defense Federal marine laboratories to address the large-scale area problems. Regional problems should be addressed by appropriate State, university, and other locally oriented laboratories.
- Although many nondefense Federal marine laboratories involved in coastal affairs have a creditable history of supporting the work of their sponsoring agencies, none currently has the multidisciplinary requirements necessary to solve large-scale area problems.
- While the Department of Interior is clearly the Federal agency most responsible for coastal-zone affairs, its marine laboratories are organizationally submerged under ten separate bureaus and offices and are generally undermanned, underfunded relative to mission, narrowly mission oriented, widely scattered, and otherwise lack the inherent capabilities to carry out the broad responsibilities of the Department.
- The three laboratories of the U.S. Army Corps of Engineers represent the principal Department of Defense responsibilities in the coastal zone. No immediate changes are envisioned in these laboratories to meet the mission of the Corps.
- None of the U.S. Navy laboratories is considered appropriate for direct utilization in coastal zone roles. Navy laboratories must continue to support ocean science and ocean engineering specifically oriented towards the Navy's uniquely military mission of national security. Support of basic and applied research which may have application in the coastal zone should be continued through the Office of Naval Research.
- None of the existing Federal marine laboratories is considered appropriate for the roles of the University/National laboratories recommended in the Commission's report. Both defense and nondefense Federal marine laboratories were evaluated and, for a variety of reasons, none was found acceptable.
- The cost and time required to provide additional and special oceanographic facilities and equipment are so great that the Nation cannot afford to scatter geographically these national resources to meet local interests. The

necessity for an immediate and effective national oceanic program demands provision for common and efficient usage by the oceanographic research community at large and requires that major Federal marine laboratories and their principal facilities be consolidated wherever possible in the vicinity of the National Oceanographic Laboratories.

- All Federal marine laboratories suffer from many common management problems, most of which result in an imbalance between quantitative and qualitative resources and assigned workload. These problems must be addressed at the highest executive levels if the Federal marine laboratories are to be a viable national oceanic resource and if these laboratories are to continue optimum support of the missions and tasks of their parent agencies.
- Although the Navy has made significant progress in consolidating its laboratory structure, and recognizing the need for various levels of marine science expertise in Navy's warfare-system-oriented centers, there is nevertheless too much diffusion of ocean sciences and ocean engineering skills, programs, and facilities within the Navy laboratories.

Based on the above findings, the Panel recommends that:

- Multidisciplinary nondefense Federal Coastal Zone Laboratory complexes should be established in each major coast zone area to carry out the responsibilities of the Federal government. Initially, Interior should consolidate various of its laboratories to form the nucleus for these complexes. Collocating other nondefense Coastal Zone Federal Laboratories, e.g., those of the Department of Commerce and the Department of Health, Education, and Welfare, with those of Interior would meet the broader needs of the Federal government.
- Should a National Oceanic and Atmospheric Agency (NOAA) be established, it would be appropriate to assign these area laboratories to NOAA.
- Interaction between the Federal area complexes and the Regional Coastal Zone Laboratories, as recommended elsewhere in the Panel findings and recommendations related to Coastal Zone laboratories, should be on a mutually agreeable arrangement.
- Federal laboratories with marine-related missions beyond the coastal zone should be colocated whenever possible to promote efficiency of utilization of support facilities and to encourage exchange of ideas on common problems. Any mechanism of either collocation or consolidation, however, must assure that statutory interests and missions of an agency are not placed in a subsidiary position within an agency with predominantly unrelated missions.

- The major Federal marine laboratories and their principal facilities should be consolidated whenever possible in the vicinity of the National Oceanographic Laboratories recommended in this report, or in the vicinity of one of the nationally recognized oceanographic laboratories.
- The Navy should continue its formation of centers of excellence and should concentrate the skills, programs, and facilities for such important ocean science and ocean engineering as man-in-the-sea, deep diving, and undersea medicine, in one collocated laboratory complex. As ocean science and ocean engineering are prime requisites for underseas warfare systems, this complex should be located at an existing Navy center capable of coping with large underseas weapons systems. Further, national and Navy programs would both be best served if this Navy center were so located as to permit close cooperation between the Navy and one of the National Oceanographic Laboratories recommended in this report.
- The senior executives of each Federal department and agency with marine laboratories should pursue a vigorous and continuing program to minimize the problems of laboratory management as reported in chapter 4 and elsewhere in the text of this report. In particular, relief should be obtained from excessively restrictive manpower ceiling controls. In addition, laboratory directors should be provided more flexibility in marine science program content and should be granted a reasonable amount of discretionary funds with which to conduct independent research.

CHAPTER 1

DISCUSSION OF COASTAL ZONE LABORATORIES

I. BACKGROUND

A. General Objectives

The position of the United States Government with respect to Coastal Zone laboratories should be guided by the needs and objectives of the Nation in the maintenance, restoration, and proper use of the coastal zone.

It is the view of the Panel that any configuration of Coastal Zone laboratories, which is eventually sponsored by the Federal government must:

- Support the decisions and programs of the Federal government
- Support Coastal Zone Authorities and appropriate State agencies
- Support a larger national involvement in maritime and coastal affairs.

The foregoing objectives will be best implemented if a series of actions with respect to Coastal Zone laboratories are taken to:

- Create a technical organization which will give adequate research and technological support to the Federal decision-making process as it relates to coastal zone matters. It must be recognized that in many areas the Federal government has a primacy of interest and as a matter of national policy it has a general interest in almost all matters related to the administration of our coastal zones. Decisions made in this area must be based on sound engineering, ecological and oceanographic concepts and principles. A group which is competent to provide this judgment must be created and maintained within the Federal establishment.
- Demonstrate the Federal government's recognition of the clear interests of the State governments in many matters relating to coastal zone management. It is in the interest of the National well being that appropriate State authorities have as much technically competent judgment to back their decisions as it is possible to give them. Thus, the Federal government should recognize the necessity to give support to marine laboratories whose missions and organizational forms are such that they support Coastal Zone Authorities within individual states.
- Reflect a policy that the Nation's interests and capabilities in oceanographic affairs must be greatly expanded. Thus, there must be a general sponsorship on the part of the Federal government of various laboratories which can conduct a vigorous research program, develop the necessary technology, and assume responsibilities for training the necessary scientists, engineers, and technicians associated with the coastal zone area. It should be the objective of the Federal government to enlarge the Nation's

activity in this area. Consequently, Federal sponsorship should be designed to yield an overall increase in the general national capability in areas related to coastal zone management.

B. Commission Recommendations

The Commission on Marine Sciences, Engineering, and Resources has examined the problems of coastal zone and estuarine laboratories and has made several recommendations for their restructuring. The Commission has recommended:

"A network of estuarine and coastal zone research institutions should be established in association with appropriate academic institutions to undertake basic and applied research on estuarine processes so that State and local Governments can have information on which to base management procedures rationally. These facilities need not be large in size, but should have adequate facilities and staff sizes exceeding the critical limit to maintain stable programs. The activity should be supported under the Sea Grant Program."

The Panel concurs with the Commission's recommendations concerning Coastal Zone laboratories. However, there are many details that must be attended to before such implementation can occur. Foremost among these are the following considerations:

- The Commission did not define the scope of the activity that should be included in coastal zone or estuarine research. Since estuarine research is often related to local problems, the critical size of such a research activity is difficult to define.
- How should the research activities of the estuarine and coastal zone laboratories overlap and be coordinated with those of the University/National laboratories?
- Since the estuarine laboratories are generally concerned with applied problems, related to the local region, should they be responsive to national needs? What fraction of the work of such laboratories should be basic research?
- A generally acceptable scheme for the classification of estuaries has not yet been developed. Individual estuaries have very little in common with each other. They have quite different topographical features, ecological systems, chemical constituents, etc. Should there really be a formal attempt to create a network of estuarine laboratories?

These considerations will be dealt with in connection with the procedures proposed for the implementation of the Commission's recommendations.

C. Review of Present Situation

1. General Comments

While estuarine and coastal zone research has been traditionally subordinate to national emphasis on deep-ocean research, the current deterioration of the coastal environment has changed this trend. The coastal zone potential which resulted in this change includes such diverse activities as mineral exploitation, commercial and sport fishing,

aquaculture, waste disposal, etc. Problems associated with multiple use of the coastal zone are inherently severe and are further complicated by the use of coastal areas for land filling and development and by dredging for channel clearing.

The need for intensive research to develop the technology and science necessary to achieve greater utilization of these offshore waters and their resources has not gone unfilled. At present, there is a large number of research activities being carried out in the estuarine and coastal zone regions. The sponsors of this intense activity include the States, various inter- and intra-state regional groups, interested universities, private profit and nonprofit organizations, and, of course, various departments of the Federal government. The latter group includes the Federal Water Pollution Control Administration, the Fish and Wildlife review, the Geological Survey, the Army Corps of Engineers, the Environmental Science Service Administration, the Navy, the U.S. Coast Guard, etc. It is clear from this large array of sponsors that a need exists for a central group which could initiate, direct, focus, and interchange the results of the research activities of various organizations.

At present, many of the research organizations dealing with coastal zone activities are subcritical in size and, therefore, ineffective. A number of Federal agencies run a multiplicity of laboratories. The existence, size, mission, and location of these laboratories are often the result of historical accident or political expediency rather than the result of a comprehensive design and management decision to create a laboratory system. Many were organized to study local or regional problems which, for various reasons, could not at the time be handled at a lower governmental level or by academic institutions. The apparent Balkanization of the Federal government's Coastal Zone laboratories led to the Commission's recommendation that Federal laboratories should be consolidated and improved. On the other hand, the problems to which estuarine research is addressed are sometimes of such a specifically local concern that it may be unwise to attempt to collect several of these organizations into one large administrative unit. Therefore, it is difficult to determine any universal measure of critical size. In fact, certain university centers, which are strong in research related to the understanding of estuarine and coastal processes, have developed around the interests and competence of single, outstanding individuals. Such groups should probably be financially supported and left untouched.

Existing Coastal Zone laboratories are to some degree effective in research (on the local situation) directed towards solution of local and regional problems. They are sponsored by academic institutions (e.g., Texas A&M), industry (e.g., Battelle Memorial Institute), states (e.g., California Marine Fisheries Laboratory), and Federal (e.g., BCF, Biological Laboratory, Milford, Conn.), or a combination of those (e.g., Virginia Institute of Marine Sciences). There is reasonably continuous communication among the Directors and scientists of Coastal Zone laboratories, and there is an effective interchange of staff, students, programs, and plans. Although these laboratories do not exist as a network, the informal process of communication provides a rather successful check on unnecessary duplication of programs, except through some academic courses. The existence of many varied laboratories has provided a diversity of opportunities for people with quality projects to find an optimum place to do their work. Selective support by several agencies has resulted in the orientation of the various laboratories towards projects of concern to the Nation.

2. Federal Agencies Missions, Problems, and Responsibilities in Relation to Coastal Zone Laboratories

As pointed out in the Commission report, there exists within the Federal agencies strong elements for carrying out marine activities. Imbedded within the many Federal departments are important activities related to coastal zone affairs.

- The U.S. Navy is directly involved in many aspects of marine science and engineering in support of its primary mission. Its laboratories and test facilities represent the strongest existing element in the program for marine technology development. However, very few of the Navy laboratories can be considered as being primarily dedicated to coastal zone problems.
- The U.S. Army Corps of Engineers is responsible for the protection and maintenance of the coast and waterways. It has developed the Nation's primary competence in coastal engineering. Its coastal engineering research center is one of the key elements in the Federal capability in this field. The U.S. Lake Survey of the Great Lakes undertakes, prepares, and publishes navigational charts and related material to study elements affecting lake level and river flow. In addition, it advises international bodies charged with the management and use of the lake waters. Finally, it has a responsibility to conduct scientific investigation of physical aspects of fresh water and to compile maps for the Army Map Service.
- The National Science Foundation supports marine atmospheric sciences as part of its basic mission to foster the Nation's scientific endeavor. It funds the development of marine and atmospheric research facilities, including oceanographic ships. It has sponsored a broad spectrum of research activities and has supported the education of environmental scientists of all kinds. The Foundation's discipline-oriented marine science and education program is inseparable from its programs in other scientific fields. These programs represent a primary resource for developing the capability for a major national commitment to coastal zone activities. The Foundation Sea Grant Program is primarily oriented to the coastal zone.
- The Department of Commerce has strong responsibilities in coastal zone areas. In particular, the Environmental Science Services Administration (ESSA) and the Maritime Administration are concerned with coastal zone facilities and air/sea interaction problems in the coastal zone regions. The Environmental Science Services Administration provides a great variety of services to the general public and specialized users. ESSA conducts both research and technical service programs to provide weather and marine forecasts and warnings, river and flood forecasts and warnings, earth description mapping and charting, marine description mapping and charting, telecommunications, and space services, and national environmental satellite systems.
- The Department of the Interior is responsible for many of the Nation's resources, and it has taken constructive action in many program areas connected with marine development. It has made great strides towards developing a comprehensive program for fresh-water management and in conservation of coastal fish and wildlife resources. Several Interior Bureaus have action programs leading to Federal or local preservation of many miles of sea shore for recreation and conservation of wildlife habitats. Interior is also responsible for the investigation and managing of the Nation's mineral resources, including those of the coastal zone region. It has the responsibility for maintaining water quality standards in all interstate waters and for preparing comprehensive pollution abatement programs.

- The Smithsonian Institution engages in world-wide research in biological and archeological oceanography, and in assembling and managing the national collection of biological and geological specimens.
- The U.S. Coast Guard, which is a component of the Department of Transportation, is heavily involved in all matters concerning coastal zone management.
- Other cabinet-level agencies that have major coastal zone responsibilities and interests include the Department of Health, Education, and Welfare; the Atomic Energy Commission; the Department of State; and the National Aeronautics and Space Administration.

Although many Federal nondefense oceanography laboratories involved in coastal zone affairs have a creditable history of supporting the work of their sponsoring agencies, a number of deficiencies do exist in Federal posture.

- Many of the Federal laboratories are undermanned and underfunded relative to their mission. The quality was criticized in the Commission report, partly because Federal laboratories involved in coastal zone affairs present an array of almost total fragmentation. Few are able to conduct adequately tasks associated with their major mission. For the major agencies, such as Commerce and Interior, which have at least nine or ten bureau-level agencies involved in coastal zone affairs, there is no corporate laboratory which provides an overall function of supplying departmental-wide support and research.
- The Federal laboratory structure tends to be oriented toward the rather narrow mission goals of individual sponsoring agencies. Because of the mission orientation of individual laboratories and their sponsors, there is little central focus of coastal scientific and engineering capabilities among Federal laboratories. The laboratories of the Fish and Wildlife Service, the Federal Water Pollution Control Administration, and the Coastal Engineering Research Center of the Corps of Engineers are not organized so that they can work closely on a routine basis.
- There is no single agency within the Federal establishment which has the responsibility of doing systems analysis relative to national problems of coastal zone usage. For example, the Commission has indicated that in the future we can look forward to changes in the patterns of ocean transportation. The principal carriers will become significantly larger and will no doubt require new, vastly different port depths, turning basins, and terminal facilities for operations. Furthermore, the number of commercial carriers may decrease drastically. In this context, our present port facilities are obsolescent. The same may be said for most coastal zone airport facilities. Unfortunately, there is no single group which has the prime responsibility of doing systems studies related to providing the Nation with modern terminal facilities. The creation of new facilities will involve legal, ecological, political, social, and environmental problems. Solution of these problems will require a broad base of technological organization that is fully versed in all aspects of science, engineering, and systems planning.

- The present configuration of Federal nondefense Coastal Zone laboratories is not organized on either a sound regional basis or a sound ecological basis. The present configuration appears to be more nearly an accident of history than a rational design of a network of laboratories. Although the existing nondefense Federal laboratories could accommodate a considerable expansion of program activities, these laboratories are not located so that collectively they allow maximum efficiency of use. Most are not of optimum size. Diverse management and political expediency in the past have led Federal laboratories to be organized so that they often do not reflect the integrity of the biogeographic provinces of our coastal zone. Finally, no Federal nondefense laboratory is a multidisciplinary complex capable of approaching coastal zone problems on a broad and balanced basis.

The inexorable trend towards more intensive use of the coastal zone is generating new research requirements throughout the Nation. The present level of funding support for such research, estimated at no more than \$25 million annually from all sources is inadequate. Additional funds and talents must be enlisted to keep pace with technical and engineering capabilities that are even now exploring and developing the coastal zone in ways that were barely conceived of a decade ago. Institutional arrangements must be developed to focus talents toward assessing the impact of these massive changes on environment, people, and resources.

3. State Agencies and Other Coastal Zone Authorities

As pointed out by the COMSER report, the responsibility to develop the coastal zone and to protect long-term values is shared by Federal, State, and local agencies. To date effective management has been hindered by the variety of government jurisdiction involved, the low priority afforded marine matters by State governments, the diffusion of responsibilities among State agencies, and the failure of State agencies to develop and implement long-range plans.

The Panel was able to identify only 17 Coastal Zone laboratories that are run by State jurisdictions. Three of these exist on the East Coast, five on the Gulf Coast region, six on the West Coast, two in Alaska, and one in Hawaii. In some States, fishery groups at a university serve many of the roles of a state-affiliated Coastal Zone laboratory.

A diffusion of responsibility for coastal zone affairs exists within State governments. Individual State agencies often deal directly with their counterparts at the Federal level. Too often, States lack comprehensive plans based on an appraisal of statewide interests in their coastal resources. In these cases, States have tended to react only to Federal plans or programs.

The key function of the Coastal Zone Authorities proposed by the Commission would be to coordinate plans and uses of coastal waters and adjacent lands and to regulate and develop these areas. The proposed Coastal Zone Authority would presumably draw on all available knowledge of the physical, biological, and economic characteristics of the States' coasts and estuaries. The Commission recommended that Coastal Zone laboratories should support the coastal authorities by conducting research and special studies and by helping to develop the necessary technology. The great diversity, resources, scope, and activities of coastal State governments will prevent adoption of a uniform administrative approach to Coastal Zone Authorities. In some States, a single authority might appropriately be given jurisdiction over the State's entire coast. In others, several groups might be established under a single authority within a State to deal with separate estuarine areas. The management of interstate estuaries will require agreements to be developed between adjacent States to delegate at least limited management authority

to an interstate body. The form of the State authority may vary from a volunteer commission with a small staff to a strong agency, such as the New York Port Authority, which has major development authority buttressed by the power to issue bonds. In some cases, interstate authorities with the Federal government as an equal partner, such as the Delaware River Basin Authority may be appropriate.

Some States have excellent laboratories and competent personnel which are usually affiliated with their Fish and Game Departments. This is apt to be particularly true in States where commercial or sports fisheries are important to the State economy. State laboratories, however, are frequently subject to political pressure. Administrators and commissioners, more often than not, are chosen for political rather than professional reasons. This factor must be taken into account when considering the quality and objectivity of the advice that Coastal Zone laboratories offer to State Coastal Zone Authorities. Despite the best of intentions the Coastal Zone Authorities will be, at least to some extent, subject to various pressures. It seems essential that the best possible legal, scientific, and technical information should be made available to Coastal Zone Authorities. Coastal Zone laboratories which advise Coastal Zone Authorities should be free to state the scientific validity of a course of action without the danger of pressure or reprisals, especially when findings will be diametrically opposed to the most financially profitable course of action.

4. University and/or Other Institutions

The Nation has considerable strength in the study of estuarine and coastal processes. This strength arises from a few "well established" research centers which are involved in some aspects of estuarine-coastal research. What the Nation does not have is well-rounded, well-equipped centers through which all important disciplines and specialties are focused in a systematic approach to understanding estuarine and coastal processes. Particularly lacking are institutions where research on the social, economic, legal, and political problems of the coastal zone can be pursued. The present university centers of strength—and there are several—have grown around the interests and competence of individuals, e.g., Pritchard at Johns Hopkins, Odum at Georgia, Haskins at Rutgers, North at Cal Tech. At other institutions (e.g., Virginia Institute of Marine Sciences, University of Rhode Island, University of Washington, Oregon State University, and Louisiana State University), an effort has been made to establish broadly based, multidisciplinary programs. Unfortunately, these efforts have not taken the form of discrete, "well-equipped" centers because of lack of funds.

With very few exceptions, coastal and estuarine studies are only a part of broad university marine interests and depend on either the strength of an individual or Federal-Aid programs that provide funds in specific categories, such as pollution research and fish and wildlife studies. What is required is focus and identifiable grouping of individuals and facilities with a definite estuarine-coastal mission. To a small extent the Sea Grant Program has attempted to develop a broad grouping of capabilities in the coastal zone.

The essence of a Coastal Zone laboratory is an orientation towards applied problems. While much basic work is necessary, it may be considered "applied," because it is directed to an end product, or because it is an essential precursor to application. Traditionally, universities have been concerned primarily with basic science, the principal exceptions being colleges of agriculture and extension stations in land grant universities. Schools of fisheries have tended to swing between applied and basic research, depending on the orientation of the administration and faculty. In Sea Grant experience, the tradition is changing. The student demand for "relevance" is one factor in accelerating the change, but the change was apparent before student unrest became a problem. Whatever the cause, universities, especially the land grant schools, are not only willing but anxious to move in applied directions. "Environmental awareness" has become a prime motivator in determining research directions, even among some senior basic scientists.

Under the present Sea Grant Program three approaches exist to the support of university efforts in coastal zone affairs. These are:

- Institutional Support, given to major universities with broadly based, multidisciplinary programs in marine research, education, and advisory services. Eight such awards have been made.
- Coherent Project Support, essentially a lesser version of institutional support, in which a university develops a program with a central theme or objective involving several projects. Universities supported under this category are expected to grow to institutional status.
- General Project Support, given for a definite period for conduct of a clearly defined project.

Under institutional support, coastal zone activities already are in progress, notably at the Universities of Rhode Island, Hawaii, Washington, Wisconsin, Oregon State, and Texas A&M. It is apparent that Coastal Zone laboratories of this type might form a basis for a national Coastal Zone laboratory network. At present they are a natural part of Sea Grant institutional programs, with separate identification but support from the institution as a whole.

Some Coherent Projects are *de facto* Coastal Zone laboratory programs without benefit of title or facilities support. The University of Delaware program is oriented to the Delaware estuary and coastal productivity and has a systems engineering approach.

The Louisiana State University program is directed to the salt marshes. The Coherent Project pattern requires only retitling in specific cases to be a Coastal Zone laboratory program.

A final observation to be made with regard to the present involvement of universities in coastal zone research is the point that, in many states, the dominant university with involvement in coastal zone research is not the State University.

D. General Considerations in Configuring a Coastal Zone Laboratory System

1. Basic Problems

It is difficult to present a unique organizational structure to support the objectives outlined above without some knowledge of the ultimate configuration of the Federal and State jurisdictions which will deal with the coastal zone in the future. On the Federal level we must, of necessity, consider an appropriate Coastal Zone laboratory network which might be used effectively within the present organization of the Federal government. Whatever configuration is adopted, it should be such that it could be easily adjusted to changes in the organization of other Federal departments. Thus, the solution suggested should be invariant to the creation of a NOAA. Indeed any solution which is recommended should be capable of being subsumed by a NOAA.

The problems of developing a laboratory configuration, "to support Coastal Zone Authorities to allow them to manage coastal interests more rationally" are even more difficult than the problems related to the organization of a laboratory configuration to support the operations and needs of Federal agencies in this area. Since the Panel is not, and cannot be, familiar with the ultimate structure, functions, or political jurisdictions of all future Coastal Zone Authorities, it is difficult to foresee how a laboratory system or network would interact with them.

Certain State organizations involved in the use of our coastal resources already have research and engineering organizations affiliated with them. In other cases, one might imagine that the Coastal Zone laboratories would be a component of the State university system, a private university or other private institution. Under such circumstances, it is not clear how a university laboratory would succeed in doing detailed and sustained technical studies that are necessary to provide information on which the decisions of Coastal Zone Authorities may be based. Should the Coastal Zone Authority be ineffective or promulgate decisions not based upon the best scientific and engineering practice, the Coastal Zone laboratories could serve as an important counterforce through publication of its research results and conclusions.

While university laboratories may reasonably be expected to carry out a sensible and comprehensive program of research, with or without the sanction of the Coastal Zone Authorities, and to undertake certain Ad Hoc studies for Coastal Zone Authorities by mutual arrangement, it is somewhat difficult to configure a permanent arrangement whereby university laboratories would, for example, make recommendations on a routine or sustaining basis or serve the function of a corporate research group for an organization such as the Port of New York Authority.

Coupling the technological output of Federally sponsored Coastal Zone laboratories to the decision-making process of Coastal Zone Authorities may be a sufficiently complex process that one of two alternatives will have to be accepted. Legislation might be written such that if a Coastal Zone Authority elected to sponsor a laboratory to assist it in its work, then the Federal government would pay a proportionate share of the laboratory operating funds without any precondition as to standards of operation or quality of laboratory performance. Under these conditions Coastal Zone laboratories would be organizational components of Coastal Zone Authorities and would be funded by a Federal grant that would be supplemented by matching funds.

The other alternative would be for the Federal government to elect not to sponsor any laboratory that had the specific mission of assisting Coastal Zone Authorities. The Federal government might attempt to sponsor Regional Coastal Zone Research Laboratories with the expectation that these laboratories would be staffed by articulate and influential members of the scientific and engineering community, who could be counted on to take the initiative to give appropriate advice when pressing coastal zone issues arose.

With regard to the third objective of Federal policy (enhanced support of national involvement in maritime and coastal affairs), the solution to the problem is considerably clearer. Here, a reasonable system already exists in the Sea Grant Program. No new laws are required to set up or to channel money into programs that are designed to stimulate interests in coastal zones. The difficulties that exist are merely matters of the size of the appropriations that have been devoted to this program.

A Sea Grant Program tends to accelerate and expand that segment of the research community that is devoted to coastal zone problems. In addition it increases the opportunities for graduate and undergraduate study in the area. Finally, it serves as a mechanism for training low-level technicians and for attracting people into industries and activities related to oceanographic affairs.

2. Coastal Zone Areas and Regions

The Panel firmly believes that the purview of the Coastal Zone laboratories should be regional. Therefore, Coastal Zone laboratories (and hopefully Coastal Zone Authorities) should be organized on a regional basis. The areas of responsibility of these laboratories should, where appropriate, transcend the seaward extension of state boundaries. The designation of coastal zone regions should be based on consideration of ecological regions, commonality of problems, and geographical factors.

We feel that any organization of Coastal Zone Authorities and Coastal Zone laboratories should reflect the integrity of major coastal zone area, which are in turn composed of certain well-defined regions. The Panel suggests that the coast of the United States be considered in terms of 10 major areas:

Northeast Atlantic
Middle Atlantic
Southeast Atlantic
Gulf Coast
Pacific Southwest
Pacific Northwest
Alaska
Hawaii
Great Lakes
Puerto Rico-Virgin Islands

To make proper regional sense, the coastal regions should in some cases transcend national boundaries. Thus, consideration must be given to the development of Coastal Zone Authorities that are, where appropriate, international in their areas of responsibility.

a. The Northeast Atlantic Coastal Zone Area

Within the continental United States the Northeast Atlantic area would extend from the mouth of the St. Croix River (Canadian-U.S. border) to the tip of Montauk Point, Long Island. If, as the Panel would recommend, coastal zone areas were to be considered international in scope, then from an ecological viewpoint the entire Canadian coast, from Cape Sable to the mouth of the St. Croix River, should be included in the Northeast Atlantic coastal zone region. Possible regions of the Northeast Atlantic area might include

- The Bay of Fundy-Minas Basin region. This would include the entire Canadian coastal zone from Cape Sable to the mouth of the St. Croix River.
- The Gulf of Maine coastal zone region. This would include the New England Coast from the St. Croix River to the coast of Cape Cod, with the dividing line being approximately at Monomoy Point.
- The Nantucket Sound, Buzzards Bay, Narragansett Bay, Block Island, Long Island Sound region. This region would include the entire Coast of Massachusetts not included in the Gulf of Maine region and the entire coastal regions of Rhode Island and Connecticut. It would include the entire New York State Coast from the Throgs Neck Bridge to Montauk Point, including the Great Peconic Bay and Gardners Bay. Fishers Island, Block Island, Martha's Vineyard, and Nantucket would be included in this region.

b. The Middle Atlantic Coastal Zone Area

The Middle Atlantic coastal zone area would include the entire coastline from Montauk Point to a seaward extension of the Virginia and North Carolina border. The regions of the Middle Atlantic coastal zone region might include:

- The New York Bight. This region would include the entire New York Bight from Montauk Point to Cape May, New Jersey. In view of the complexity of this region, it might be subdivided into the following districts:
 - The Long Island wetlands district. This district would stretch from Montauk Point to Far Rockaway.

- The Port of New York District. This district would include Far Rockaway, Jamaica Bay, New York Harbor, Newark Bay, the Coast of Staten Island, Raritan Bay, and all coastlines as far as Sandy Hook, New Jersey.
- The Jersey barrier beaches district. This district would include the New Jersey Coast from Sandy Hook to Cape May.
- The Delaware Bay region. This region would include the Coast of New Jersey, Cape May to the mouth of the Delaware River, and the Coast of Delaware as far south as Cape Henlopen, Delaware.
- The Delmarva region. This region would include the Delmarva Atlantic Coast Region extending from Cape Henlopen, Delaware to the Virginia-North Carolina line.
- The Chesapeake Bay region. This region would include Chesapeake Bay proper, and such major estuaries as the Potomac River, the York River, the James River, and the Rappahanock River.

c. The Southeast Atlantic Area

This area would extend from the seaward extension of the Virginia-North Carolina border southward to the southern tip of the Florida Peninsula. It might be organized into three regions:

- The North Carolina region. This region would extend along the entire coast of North Carolina from the seaward extension of the North Carolina-Virginia border to the seaward extension of the North Carolina-South Carolina border. This region would include responsibility for Currituck Sound, Albemarle Sound, the Pamlico River estuary, and the coastal off-shore beaches of North Carolina.
- The South Carolina-Georgia region. This region would include the entire coast from the seaward extension of the North Carolina-South Carolina border to the mouth of the St. Mary's River between Georgia and Florida.
- The Florida Atlantic region. This region would extend from the St. Mary's River, along the coast of Florida to Key West at the extreme southern tip of the Florida mainland. It would include Florida Bay, the Florida Keys, and Dry Tortuga.

d. The Gulf Coast Area

The Gulf area would extend from the southern tip of the Florida Peninsula to the mouth of the Rio Grande River. If international considerations were to be considered, this area should probably be extended as far south as Tampico in Mexico. In the American segment of the Gulf Coast three regions would be considered:

- The East Gulf region. This region would include the entire coast of Florida as far west as the mouth of the Perdido River.
- The Central Gulf Coast region. This region would include the Gulf Coast from the seaward extension of the Alabama-Florida boundary to the mouth of the Sabine River, which is the seaward extension of the Texas-Louisiana boundary.

- The Western Gulf coastal zone region. This region would include the entire coast of Texas from the mouth of the Sabine River to the mouth of the Rio Grande.

e. The Pacific Southwest Area

On an ecological basis the Pacific Southwest coastal area should include sections of the coast of Baja, California. In particular, a logical extension of the Pacific Southwest coastal zone area would extend from the seaward extension of the Oregon-California border to Punta Eugenia in Baja, California. This region should consist of three separate regions.

- The Southern California coastal zone region. This region would extend from Point Conception to Punta Eugenia.
- The Northern California coastal region. This region would extend from Point Conception to the California-Oregon border.
- The San Francisco Bay coastal zone region.

f. The Pacific Northwest Area

This coastal zone should logically include the entire coast of the states of Oregon and Washington. The coast of Vancouver Island and associated areas in British Columbia should, if possible, be included in this region. This coastal zone would be broken into two regions:

- The Pacific Northwest coastal zone region. This region would include the Oregon coast, the Pacific coast of the State of Washington and the Pacific Coast of Vancouver Island.
- The Puget Sound region. This region would include all of the coastal regions bordering the Strait Juan de Fuca, Puget Sound, and the Strait of Georgia, including all inlets which enter these waters.

g. The Alaskan Coastal Zone Area

This region should include the entire Canadian and Alaskan Coast from Queen Charlotte Strait northward. The logical regions of the Alaskan coastal zone region would include:

- The Gulf of Alaska region. If the coastal zone regions were to be international in extent, this region would extend from Cape Scott on the northwest tip of Vancouver Island to Unimak Island. If this were not to be an international coastal zone region, it would include only the Alaskan coast as far south as the Canadian-U.S. border.
- The Aleutian Island coastal zone region. This region would include all of the Aleutian Islands west of Unimak.
- The Bering Sea region. This region would include all of the Alaskan coast from Unimak Island to Point Hope. St. Lawrence Island and Nunivak Island would also be included.
- The Alaskan Arctic region. This region would extend eastward from Point Hope to the Canadian-U.S. border.

h. The Hawaiian Island Coastal Zone Area

The Hawaiian Island coastal zone area would include the entire coastal zone of the Hawaiian Archipelago.

i. The Great Lakes Coastal Zone Area

The Great Lakes coastal zone area would include all five of the Great Lakes. The relevant Coastal Zone Authorities would, with one exception, be international in character. Because each of the Great Lakes represents a separate ecological problem, it is suggested that this area be divided into five separate regions:

- The Lake Superior coastal zone region.
- The Lake Michigan coastal zone region.
- The Lake Huron coastal zone region. This region would include Lake St. Clair, North Channel, and the Georgian Bay.
- The Lake Erie coastal zone region.
- The Lake Ontario coastal zone region.

j. The Puerto Rico-Virgin Islands Coastal Zone Area

This would include the entire coastline of Puerto Rico and the Virgin Islands.

3. Multidisciplinary vs Single-Purpose Agency Laboratories

Laboratories are normally organized to encompass either a single professional discipline or they are multidisciplinary in character. Multidisciplinary laboratories are typically set up by major corporations to act as a corporation-wide research center for all corporate components or subgroupings.

It is the strongly expressed view of the Panel that Federal Coastal Zone Laboratories should be multidisciplinary in scope. They should be so organized and so staffed that they can be responsive to the needs and problems of the many Federal agencies that are involved in coastal zone matters. It is the Panel's feeling that a broadly based approach to coastal zone problems is far superior to an approach based upon laboratories that are organized about a single discipline or the needs of a single agency in pursuit of its mission.

Multidisciplinary groupings have traditionally provided considerable interdisciplinary cross fertilization and they have proven to be one of the hallmarks of all successful corporate laboratories. For example, fishery environmental research without adequate geological or hydrological support can lead to incomplete or erroneous conclusions. Such studies are more efficiently and more competently performed if there are groups within one organization that are broadly based. Major disciplines such as marine biology, zoology, geology, hydrology, chemical and physical oceanography, and engineering should be part of most Federal Coastal Zone Laboratories. Many of these laboratories also must have capabilities in systems ecology and for working with mathematical and physical models. The interdisciplinary character of such laboratories would give the Coastal Zone Authorities access to a broadly based group capable of commenting on various aspects of problems as they evolve, and also capable of suggesting alternative solutions to proposals that threaten coastal zone resources or processes.

The major difficulty associated with the support of a multidisciplinary laboratory is the fact that recipients of the knowledge are often interested in the output of only one component of the laboratory. Thus, if all Coastal Zone laboratories were multidisciplinary in character, the Bureau of Commercial Fisheries would still be interested primarily in the research related to fisheries. It would not be in a position to fund or sponsor research whose final product would more properly be of interest to the Corps of Engineers or to the Geological Survey.

Despite some of the well known shortcomings of multidisciplinary laboratories, the Panel feels that broadly based laboratories are nonetheless desirable. Coastal zone problems are sufficiently complex that they form a basis for synthesizing the research effort of many basic scientific disciplines. One would hope that through the matrix of multidisciplinary Coastal Zone laboratories a confluence of technical studies would result which would produce a basis of knowledge and information to allow us to manage our coastal zone areas in an optimal manner.

4. Size, Number, and Critical Mass Considerations for Coastal Zone Laboratories

The Panel believes that the Coastal Zone laboratory network should show a congruence of areas of interest with coastal zone areas and regions and with the jurisdictions of Coastal Zone Authorities. At the Federal level, Coastal Zone laboratories should be devoted to problems in relatively large areas, while at the state or university level the laboratory organization should be based on coastal zone regions. The Federal laboratories should be interdisciplinary in character and should have enough staff competence, physical facilities, and breadth of intellectual interest to execute a useful program of research involving all aspects of a coastal zone area. Laboratories for coastal zone regions, which would be oriented to problems of a local nature, would not necessarily have to be as broadly based in the technical disciplines as the major area laboratories. On the other hand, they should not be restricted only to specific research needs of the region.

The proper size of the staff of a coastal zone laboratory can be estimated only approximately. Clearly, the appropriate staff size would depend on whether or not the laboratory was involved in area or regional problems, and also upon such factors as whether a laboratory was a single-purpose laboratory or a multidisciplinary laboratory. At a multidisciplinary laboratory devoted to research, the organizational structure is normally based on research subgroups that are oriented towards a single professional discipline. To achieve criticality of research productivity and intellectual vitality, these research subgroups should have a minimum of about 15 or 20 professionals. This figure is based on the organizational experiences of many government and private laboratories. If eight to ten separate disciplines are pursued in a multidisciplinary laboratory, then a good size for a professional staff would be between 150 and 200.

In successful major laboratories, the professional staff is typically supported by approximately one and one-half support personnel per professional staff member. This figure is not absolute and clearly will vary greatly with the nature of the work. Thus, it would appear that an appropriate staff size for a Federal Coastal Zone Area Laboratory that pursues ten separate disciplines would be 400 or 500 people.

The costs of such a laboratory would vary greatly with the nature of the work carried out and the expense of supporting facilities. Typically, it is found that approximately \$35 to \$40 thousand is required to support one direct charge research scientist. This figure would include the scientist's salary and a proportional share of the expenses of overhead employees, the cost of minor procurements, supplies, travel, etc. Thus, for a laboratory with a 200-man professional staff, an annual operating budget of approximately \$7 to \$8 million a year would be required. For a national network with 10 Federal Area Coastal

Zone Laboratories, an annual budget of the order of \$70 to \$80 million would therefore be required. The cost of operating research ships or procuring special facilities would not be included in the costs outlined above. It should be noted that the nucleus for such facilities now exists. In some cases, such as the Federal complex at Narragansett, the existing facilities are already adequate to serve as a Federal Coastal Zone Area Laboratory.

It is the view of the Panel that laboratories which are connected with coastal zone regions should either be university oriented or should be directly affiliated with Coastal Zone Authorities. Because of the variability of problems in different regions, these laboratories would not necessarily encompass as many disciplines as would be encompassed in a Federal Area Coastal Zone Laboratory. These regional laboratories would of necessity be somewhat smaller in overall size than the area laboratories. Nonetheless, the unit subgroup size, which would define the number of investigators involved in the study of a given discipline, would probably be about the same.

The budgetary support required for professionals devoted to regional problems would not differ appreciably from the budgetary requirements of major area laboratories. The same rules of thumb obtain. If there were a total of approximately 30 regions, approximately 20 to 25 might have separate laboratory systems. One can assume that, for purposes of planning, regional laboratories would have annual budgets of approximately \$3 to \$4 million. Thus, the network would require an annual expenditure of between \$75 and \$100 million.

As a rough guess, the overall annual operating cost for all Coastal Zone laboratories, both area and regional, would be between \$150 and \$200 million a year. Much of this money would already be included in existing appropriations.

5. Administrative Considerations Relative to Coastal Zone Laboratories

a. Agency sponsorship

A Coastal Zone laboratory "network" which is appropriately sized to reflect the Nation's coastal zones management problems will be a large-scale undertaking. If a comprehensive approach is undertaken at the Federal level then the laboratory network should be administered and sponsored from a relatively senior level within the sponsoring agency. As ultimately envisaged in this report, approximately three approaches to the Coastal Zone laboratory problem should be undertaken.

One approach sees a Federal laboratory effort which would centralize multidisciplinary research in a number of area Coastal Zone laboratories. These laboratories would undertake research and technological development programs for bureau-level agencies and would represent a consolidation of research functions of several bureaus. Ideally, the Federal Area Coastal Zone Laboratory System (FACZLS) should report to its parent department at the level of an Assistant Secretary for Research and Development. These laboratories would represent corporate research centers which would attend to departmental-wide problems in a given coastal zone region.

If no major departmental reorganization is undertaken within the Federal government, then the area Coastal Zone laboratories should come under the purview of the Department of Interior. The area Coastal Zone laboratories would initially represent a consolidation of all Department of Interior laboratories and research functions having significant involvement in coastal zone matters. As these laboratories develop stature and capability, other Federal research efforts associated with the needs of bureaus outside of the Department of Interior should be collocated on the sites of the Federal area Coastal Zone laboratories. Various host-tenant relationships can be developed between the regional laboratory and the other agencies. The major laboratory complex might gradually assume responsibility for

physical facilities, for the procurement of research equipment, accounting, payroll, and common user facilities such as libraries, computers, data storage banks, etc.

Historically when Federal sponsorship is involved, considerable local pressure usually arises when any attempt is made to consolidate laboratories or their functions. Because such "political realities" cannot be ignored, it is the Panel's view that the process of consolidating laboratories would require a period of several years for full implementation. Nonetheless, all appropriate Federal research and development functions within a major coastal zone region should be moved to central locations as rapidly as possible. The excess laboratory sites would be downgraded to the status of field stations which would be subordinate to the central regional laboratory group. As the process of attrition takes place, the field sites would be phased out or maintained at a minimal level necessary to expedite research of a highly localized nature. In the meantime, a moratorium should be called on the construction of new coastal zone type laboratories.

In the event of a reorganization along the lines recommended in the Commission report, then it would seem necessary and proper to assign these Area Coastal Zone Laboratories to NOAA. Presumably, NOAA would be organized in a manner that would parallel a cabinet level Federal department. A single Office should be established in NOAA to direct the laboratory system. This office would be responsible for continuity of funds, long-term development of physical facilities, long-term planning, program review, and other functions normally provided by an office for centralized laboratory management.

Nongovernment laboratories sponsored to encourage an expansion of national competence in coastal zone affairs will in all probability be university or university associated laboratories. Clearly, the National Science Foundation would be the proper mechanism for the administration of such laboratory groups until a NOAA is created. For each region, the National Science Foundation would establish core facilities at selected institutions. It would fund and review programs on a regional basis to assure that the interests of the region are being responded to in a proper manner and that the quality of research and technological development was appropriate to the regional problem.

b. Funding

The problems of funding a Coastal Zone laboratory network are in many respects quite similar to those of funding University/National laboratories.

For those Coastal Zone laboratories that are Federal in character, the pattern of funding should be such that some operating funds are supplied in a block from the parent agency. These funds should be sufficient to cover most of the overhead employees (guards, librarians, computer operators, ship crews, administrative staff, etc.) and to provide for the upkeep of physical facilities. Approximately one-fourth to one-third of the funds available to the Federal Area Coastal Zone Laboratory should be used to generate and prosecute internally generated programs.

In addition to the independent research and development funds, a very significant fraction of the center's funds should come from bureau-level sponsoring agencies which have mission-oriented research that they wish to have undertaken. Bureau funds would be somewhat competitive in nature in that the sponsoring bureaus or agencies would not have a mandatory requirement to fund research activities at a particular Area Coastal Zone Laboratory. Past experience has shown that when a modified free enterprise system is instituted at a Government laboratory, the vitality of the organization appears to increase greatly. Thus, to insure survival, individual Federal laboratories would have to demonstrate their responsiveness to the needs of sponsoring bureaus and agencies.

Provision should also be made so that the Federal laboratories can receive funds from a multiplicity of agencies. Thus, while a Federal Area Coastal Zone Laboratory

might be operated by either NOAA or by the Department of Interior, it should be able to receive funds from NASA, AEC, or the Public Health Service, as well as from those bureaus which constitute the component parts of NOAA or the Department of Interior. This procedure would allow Government agencies to shop for research support and would put pressure on the laboratories to do work that is responsive to overall Federal needs.

Funds in support of university-associated Regional Coastal Zone Laboratories must also have a certain degree of long-term stability. The arrangements between the National Science Foundation and these laboratories would not necessarily guarantee an annual budget. However, a commitment would exist on the part of the Federal government to support certain core facilities that are necessary for the operation of the laboratory. Individual laboratories would be able to apply to their normal sponsors for funds to support specific research programs that would be appropriate for coastal zone research in their region of interest. These laboratories would be able to accept funds from Coastal Zone Authorities, Federal agencies, and from private sources such as university endowments. The ability to have multiple sponsorship and to be essentially guaranteed institutional stability would insure that these groups would maintain a vigorous independence which would allow them to provide totally unbiased research and advice free of overt political pressure.

c. Congruence with Coastal Zone Authority Jurisdictions

Any configuration of Federally sponsored Regional Coastal Zone Laboratories must be organized in reasonable congruence with the jurisdictions of Coastal Zone Authorities. It is extremely important to develop a commonality of authority, jurisdiction, and regional focus for coastal zone research programs. It is felt that local interests will be best served if research is sponsored on a regional basis. Specialized research, knowledge, and observation will then be available, and there will be little question of local problems being settled by "outsiders" who are not familiar with the local situation. Further, if Regional Coastal Zone Laboratories are organized along lines which parallel the jurisdiction of Coastal Zone Authorities, then the local State governments will be able to appropriate funds for laboratory organizations which fall within State interests.

Federally sponsored laboratories should be organized only on the basis of major coastal zone areas. The Federal government has coastal zone responsibilities and interests which exceed, in geographic extent, those of the States. In addition, because many coastal zones should be considered in consonance with the coastal zones of contiguous foreign countries, the Federal government must organize a laboratory program to include international groupings.

If the Federal government does not have the resources to organize ten Area Coastal Zone Laboratories, it might begin by organizing laboratories which would serve two or three contiguous coastal zone areas (e.g., there might be one Coastal Zone Laboratory for the Pacific coast, one for the Great Lakes, one for the Atlantic, and one for the Gulf coast). Hopefully, Federal research interests and funding resources can be particularized to the broad and natural ecological regions which exist in each coastal zone area.

d. Program Review and Evaluation

Any Federally sponsored program must be subject to a process of program review and evaluation in order to determine whether the national needs are being served in an optimum manner. Since various laboratory forms will exist within the network of Coastal Zone laboratories, various mechanisms must be used for program review and evaluation.

It is recommended that within each major coastal zone area an annual review take place. This review will be accomplished by a board composed of representatives of sponsoring agencies within the Federal government, representatives of each of the regional

Coastal Zone Authorities, and representatives from the academic community in other coastal zone regions. The work of all of Coastal Zone laboratories, both Federal and university-affiliated, should be subject to a single comprehensive review program. This review program should require the laboratories to outline the research accomplished during the past year, the major problems of the current year, and future research to be undertaken. An evaluation should be submitted defining the technical import of the laboratories' findings.

The regional review process should evaluate the adequacy of the work relative to the regional problems and it should make recommendations as to the appropriate level of effort that should take place in future years. In so doing, a well defined rationale for the level of effort should be developed. It is anticipated that this rationale would have considerable local sponsorship and endorsement.

The senior agency which sponsors and controls the national coastal zone program would submit an annual report to Congress which would outline the laboratory accomplishments and set forth the program needs for the forthcoming year. This agency would defend the relative allocation of funds to different components of the overall national coastal zone program.

The comprehensive regional research review would take place after other reviews have occurred at lower levels. Thus, all research proposals from groups within local regions would be subject to a well defined process of evaluation. Peer groups from other regions should review the research program and make recommendations to the sponsoring agencies.

Subordinate reviews should be made on both a programmatic and disciplinary basis. Programmatic reviews should be undertaken by sponsoring agencies in those aspects of the laboratory's mission-oriented work in which the agencies are most interested.

e. Flexibility of Operation at Federal Laboratories

The Panel believes that research efforts at Federally operated Coastal Zone laboratories will not be successful unless the laboratories are granted considerable flexibility of operation. While a number of Federal laboratories have outstanding records of scientific success and productivity, one can also point to the rather dismal records of certain Federal research establishments. The poor quality of the latter laboratories is usually attributed to one or more of the following causes:

- Artificial constraints on personnel in both numbers and grade level, which result in an inability to attract, promote, and hold talented individuals.
- Inadequate financial and technical support which frequently results in talented scientists being unable to carry out their programs because the resources available to them are simply inadequate to the tasks.
- Cumbersome centralized control and reporting systems which encourage people to make minimum technical innovations, rather than attempt to upgrade or to change the program.

To be successful, a Federal laboratory should have reasonable continuity of funds for its core program, a relatively simple after-the-fact reporting and review system for at least part of its program, and a certain amount of funds available for programs that are developed by the laboratory staff on a speculative basis. In addition, budgetary and ceiling-point constraints should be sufficiently relaxed that reasonable people can be attracted and

held. The poorer Federal laboratories are normally characterized by very low average-GS-grade levels. As a result, they cannot compete for, or retain, either senior or competent people. If overall ceiling controls must be established, then the total number of Federal laboratories should be reduced so that a relatively few competent laboratories can be kept at a critical level. In the past, many Federal laboratories suffered from being marginal in both personnel and budgetary support levels. By consolidation of budgetary and ceiling point resources, critical size laboratories can be established.

Federally-operated Coastal Zone laboratories should not be totally captive to a single bureau or agency. Total dependence on a single parent organization at the bureau level tends to be extremely restrictive to the operation of a laboratory. The laboratory administration has very little flexibility and must, in some sense, be overly responsive to the parent agency. The more successful laboratories in the Federal government are operated under circumstances which allow the local laboratory management considerable independence by apportioning a significant amount of unprogrammed funds which can be used according to the internal dictates of the laboratory. The performance achieved from these funds is reviewed after the fact. It is recommended that Federally sponsored Coastal Zone laboratories be operated in this pattern.

f. Long-Term Planning

The concept of a network of Coastal Zone laboratories implies central direction and review. Above and beyond such factors as the interchange and comparison of programs and the common use of facilities, a network of Coastal Zone laboratories should be characterized by common long-term planning at a departmental level. Thus, within the department which is ultimately assigned responsibility for overseeing the operation of the coastal zone network, a group should be established to provide long-term plans for the development of new competences and facilities. A planning group should exist which can make overall projections of manpower, budget, and facility requirements for the departmental laboratory system. These plans should be centralized within a single program for presentation to Congress on a yearly basis. For the case of Federally operated Coastal Zone laboratories, agency competition for funds to build new physical facilities would be eliminated by centralizing the planning function at a departmental level.

In addition to the planning, which would be carried out for Federally operated laboratories, long-term planning would also be required for the university-associated Coastal Zone laboratories. The National Science Foundation, or other principal sponsors, would be required to submit, on an annual basis, a realistic projection of the growth, development, and budgetary needs for the following five years. The projections of the National Science Foundation would have to be coordinated with the projections for the Federal laboratories.

The planning function would not affect research decisions per se. It is clearly recognized that good research does not result from following plans that were laid out five years previously. The objective of centralized planning is to achieve facilities and staff size that are in consonance with the available resources and that represent the optimum allocation of resources which can be made available to the Coastal Zone laboratories.

II. AVAILABLE OPTIONS

In order to implement the propaedeutics discussed above, the Federal government has a number of options which might be pursued. These are discussed below in two contexts (e.g., support of Federal agencies, support of Coastal Zone Authorities).

A. Coastal Zone Laboratory Configurations to Support Federal Agencies and Their Missions

1. Consolidated, Multidisciplinary Coastal Zone Laboratories

Concept

The Federal Government would consolidate all coastal zone research and technological undertakings into one or more centralized Coastal Zone Laboratories whose missions are to carry out multidisciplinary research related to the management and understanding of the coastal zones of our Nation. A number of suboptions would be subsumed under this context.

- Form one single department-wide Coastal Zone laboratory which would synthesize all of the research carried out by various Federal agencies related to the coastal zones.
- Form a number of centers organized about large regional interests. In this case, approximately four Coastal Zone laboratories would be created to cover the Pacific coast, the Great Lakes, the Atlantic coast, and the Gulf coast.
- Create one central multidisciplinary laboratory for each of the major coastal zone areas defined above.

Whatever suboption is selected, management of the Federal Coastal Zone laboratory system should be centralized at the level of an Assistant Secretary of a major Federal department. If there were to be no reorganization of our Nation's maritime effort, then this Federal Coastal Zone laboratory system would be centralized in the Department of the Interior, and each of these laboratories would be known as a Department of Interior Area Coastal Zone Laboratory. If a National Oceanic and Atmospheric Agency were created, then it would presumably have control of the proposed laboratory network.

Advantages

This configuration would allow the Federal government to aggregate its research activities into units of critical size which could be given a central focus. Broadly based activity would take place in these centers. Because of the intellectual cross-fertilization which could be anticipated, a high grade of research and technological achievements could be anticipated. In addition, a reasonable economy of costs would be achieved as a result of the consolidation of certain overhead functions. Finally, research could be undertaken on a broadly based technological scale that is not presently available in Federal laboratories which operate in support of the mission of a single bureau. Research on local problems would generally be relegated to Regional Coastal Zone Laboratories.

Disadvantages

Multidisciplinary, broadly based laboratories tend to be somewhat diffuse in their support of the mission of any individual agency. Establishment of a multidisciplinary laboratory would tend to disrupt a number of very excellent working relationships which currently obtain between bureau-level organizations and their support laboratories. The possible diffusion of effort which might result from an attempt to serve many bureaus might tend to weaken the support given to individual Federal agencies. In addition, Congress reviews the budget at the bureau level rather than at the departmental level. As a result, the present budget structure, and the Congressional review process associated with it, would be subject to considerable and rather painful revision. Because bureau level activities would no longer have a specific responsibility for the maintenance of a laboratory effort, the degree to which these agencies would fight for support of laboratory funds is unclear.

Consolidation of function into central research laboratories would represent a loss of a considerable amount of local concern and knowledge. While the present Federal laboratories are frequently subject to the criticism of being undersized and diffuse, it is clear that the Federal laboratories in some cases do have a considerable involvement with extremely local problems. Centralization of research and development, with the concomitant abandonment of outlying facilities, would represent a change in past practices. The Federal laboratories would no longer be able to particularize their research to relatively local problems.

2. Maintain and Strengthen Federal Laboratories which Support the Mission of Single Agencies.

Concept

Under this concept, the Federal government would maintain the present organizational relationship between bureau-level agencies and their existing research and development laboratories. While certain consolidations and efficiencies would presumably be effected, the resulting laboratory network would still be dedicated to the support of a single agency. For example, a number of the present laboratories run by the Bureau of Commercial Fisheries might be agglomerated into somewhat larger individual units and organized on broader ecological and geographical bases. However, the final laboratory configuration would still be oriented towards serving the needs of the Bureau of Commercial Fisheries.

Advantages

This arrangement would allow agencies which have statutory responsibilities to be assured of continued technical support. Internal organizational changes could be made to improve efficiency. A series of laboratories dedicated to serving the mission of a parent bureau would exist. This would be more or less a continuation of the status quo and would allow existing Congressional review processes to continue. The laboratories would continue to receive their total support from their parent bureau. It is anticipated that the parent bureau would wage a vigorous campaign for the budgetary and facilities support of the laboratories because of the bureau identification with the laboratories.

Disadvantages

This option would essentially fail to change the status quo in a substantive way. It would represent a continuation of the present fragmented responsibility for both the research and the administration of various components of our coastal zone problems. Indeed, even if the existing laboratories were to be consolidated into technically more efficient units, the fact that they would still be oriented towards the needs of a single sponsoring agency would tend to discourage a broadly based multidisciplinary attack with a central focus on the overall problems of a particular coastal zone region.

3. Operate a Contract Research Program to Support the Objectives of Mission-Oriented Agencies.

Concept

Under this proposal, the Federal government would downgrade the role and responsibilities of its in-house laboratories in matters related to coastal zone research. As these laboratories would suffer cumulative attrition, Federal agencies would obtain research and technological support through the mechanism of a contract research program at universities, at nonprofit research centers, or at industrial laboratories. The model that would be followed here would be that of the contract research program of the Office of Naval Research. It would represent the predominant mode of the Federal government's participation in coastal zone research and technology.

Advantages

The advantages of this option are that the sponsoring agencies would be free to contract with those organizations which are most competent to satisfy their research needs. The Federal government would not bear a long-term responsibility for the staff of Coastal Zone laboratories, nor would it be required to procure support for special-purpose facilities. In addition, because research contracts would be awarded competitively, the competition so engendered might stimulate a high level of technical performance. This procedure would remove all the inflexible constraints that frequently occur when the Federal government attempts to accomplish its research with in-house organizations. The research capabilities of laboratories which did the research would not be based on artificial limitations as to grade level or ceiling points. In a larger sense, it might be assumed that this option would go far toward stimulating the growth of a research industry in the United States which was oriented toward coastal zone research. Thus, the Federal government might achieve through this policy the twin objectives of supporting its own coastal zone decisions and of encouraging the existence of a research complex devoted to coastal zone matters. Finally, because the Federal government often finds that it is uneconomic to develop and to retain personnel with exotic technological specialties, these could be secured on a consulting basis, only as needed. As a result, there would not be a need to support highly specialized research personnel whose activities are only of occasional value to the Federal government's program.

Disadvantages

This option would fail to provide the continuity and long-term dedicated support which is found in the more successful Federal laboratories. A certain degree of pressure always exists when research is subject to competitive bidding among many organizations. Organizations which hope to compete for research contracts tend to slant their proposals and their results in a way which they feel will conform to the presumed prejudices and known opinions of the sponsoring agency. As a result, the quality of research available to the Federal government might deteriorate. In addition, because contracts would exist either on a project or a yearly renewal basis, the Federal government would have no repository of personnel with broad backgrounds and cumulative skills in the areas of interest. The cumulative experience and corporate memory which is found in the better in-house laboratories would be lost. The Federal government would be extremely dependent upon the skill and ability of contract administrators in parent agencies rather than upon the capabilities of serious and dedicated working scientists in a Federal research laboratory.

4. Smithsonian Model

Concept

Under this concept, the Federal government would establish a number of laboratories that would be administered by either an organization modeled on the pattern of the Smithsonian, or by the Smithsonian itself. Multidisciplinary regional laboratories might be established within the concept of a "Federal University Structure." The operation of these laboratories would follow the pattern set by the present research component of the Smithsonian Institution.

Advantages

The Smithsonian's mode of operation gives the Federal government considerable flexibility in that the operation involves components that are both under the Civil Service system and outside of the system. Many of the difficulties related to Civil Service operation are thus obviated. In addition, the Smithsonian has sufficient prestige and seniority

within the Government that it reports to the President at a level that is approximately equivalent to a Cabinet-level agency. The traditions of the Smithsonian for carrying out research programs are well established, and thus there is a reasonable prognosis for research being conducted at a competent level.

Disadvantages

Under this model, the responsiveness of the laboratory organization to the sponsoring agency would be unclear. The laboratory would not be a component of any department or bureau which had an operational responsibility for coastal zone management. The applied aspects of research in the coastal zone might be considerably diluted. In addition, the Nation has had no experience in the operation of a Smithsonian-type research organization on a scale which would be required for an appropriate national attack on coastal zone problems. If the magnitude of the effort required \$150 to \$200 million a year, the managerial capabilities and techniques of a Smithsonian type of management would have to change substantially. The sheer magnitude of the operation would probably cause it to evolve in a manner so that the operation would closely parallel normal Federal laboratory management techniques. As a result, the country would have a laboratory system with a number of disadvantages unique to this form of organization, but without some of the advantages which obtain in the better Federal laboratories.

B. Regional Coastal Zone Laboratory Configurations in Support of Coastal Zone Authorities

The Panel anticipates that Coastal Zone Authorities will consider and attempt to resolve problems related to an extremely wide spectrum of activities associated with offshore development. The following subjects would presumably be appropriate for Coastal Zone Authority attention:

- The provision of sufficient and appropriate marine recreational facilities to state residents
- The maintenance of local water quality
- Maintenance of high-level concentrations of living marine resources
- The recovery of underwater mineral wealth
- The prevention of beach erosion
- The creation of modern transportation facilities
- The provision of information to permit a proper mixture of development and uses that recognize equally the laws of ecology along with those of thermodynamics, supply and demand, etc.
- Keeping long-term options open.

It is obvious that no laboratory system can be uniquely structured which can focus on all of these problems. The development of a laboratory system which will reflect the structure of the Coastal Zone Authorities, which historically have originated via political considerations, represents an additional complication. Furthermore, some Coastal Zone Authorities are extremely provincial in makeup while others, like the Chesapeake Bay Authority, are interstate in character. This consideration introduces an even more difficult restraint in developing a laboratory structure.

On the other hand, there are certain features that all estuarine and coastal zone laboratories should have in common. In general, they all should have an applied orientation. The types of problems that are appropriate for their attention are those for which immediate solutions are required. In providing the scientific backup for coastal zone management, these laboratories should be immune from political pressure. Because intelligent coastal zone management requires a mixture of information concerning the biology, geology, and hydrology of the coastal zone, it is desirable that these laboratories be multidisciplinary in scope.

1. Maintain and Strengthen Present Laboratories

Concept

The present system of coastal zone and estuarine laboratories would be strengthened and developed through increased funding, and the laboratories would be encouraged to engage in multidisciplinary attacks on local problems. Many of these laboratories are already a part of local State universities and are eligible for Sea Grant support. New facilities appropriate to local needs would be federally financed and constructed to increase the capabilities and scope of these local laboratories. A series of scholarships could be provided so that a steady flow of trained coastal zone scientists would be maintained. A loosely composed network of these laboratories would be established, based on supplementary central funding (Federal) and review. Interaction between those laboratories would be encouraged by an exchange of personnel and equipment and by sponsoring interlaboratory seminars.

Advantages

Generally speaking, solutions to local problems can be provided with more dispatch by specific attention to these problems from estuarine laboratories with more local missions and interests. The responsibilities of the state and local authorities toward such research would be unimpaired by this option. Local funding, and consequently local interest, in the health and vigor of the Regional Coastal Zone Laboratory would be maintained. Upgrading of the research facilities would result in a concomitant upgrading of research activities in an evolutionary manner with minimal upheaval. Since local problems would be given primary attention, little overlap would occur and the tedious process of coordination of research activities would be unnecessary.

This option would be best suited to insure close cooperation between Coastal Zone Authorities and Regional Coastal Zone Laboratories. The presently existing array of "regional" Coastal Zone laboratories has developed as a result of a combination of political and economic pressures and is therefore most responsive to local requirements.

Disadvantages

The rather fragmented and unrelated coastal zone and estuarine research now being employed would be perpetuated by the adoption of this option. Local laboratories would be upgraded uniformly, and all existing laboratories would grow in a fashion unrelated to their potential or quality. Local problems would continue to receive emphasis, and only short-range solutions to immediate problems would result. More basic, and consequently more important, questions such as estuarine classification would remain unattended. Unique and costly facilities would be duplicated at various research institutions, and there would not be efficient utilization of such facilities.

2. Area Coastal Zone Laboratories

Concept

The coastal zones of the United States would be arbitrarily divided into the ten geographic regions enumerated previously. In each of the major coastal zone areas, a central Coastal Zone laboratory would be developed. Preferably, it would be located in the vicinity of, or contiguous to, some local university with coastal zone interests. At this Regional Coastal Zone Laboratory, research activities, cutting across State interests but pertaining to that region, would be initiated. Mathematical models of the local biological and ecological conditions would be developed. In addition, studies of air-sea interactions, human effects on coastal zones, marine geology, and the determination of mineral potential would be investigated.

Interactions between these central regional laboratories and the local laboratories would be encouraged through the use of shared facilities, manpower, and program development. Financial assistance would be made available to the existing laboratories through a Sea Grant type of organization.

Advantages

Local estuaries and coastal zone laboratories would be encouraged to continue their research on local problems, but at the same time they would be encouraged to widen their scope of activity through their interactions with the Regional Coastal Zone Laboratory. The Area Coastal Zone Laboratory would be the focal point of research activity in each area. In addition, it would coordinate its scientific activities with those of other area and regional laboratories. By this means, a network of interacting coastal zone and estuarine laboratories would be established.

Unique and expensive facilities would be housed at the area laboratory and would be made available to all the local regional laboratories in that area. Efficient utilization of such shared facilities would be insured by user committees. Work of a more involved nature, beyond the capability of an individual local laboratory, would be undertaken at the area laboratory, or it would be divided into problem areas which could be handled by local laboratories.

Disadvantages

The division of the major coastal zone areas has been made primarily on a geographic basis. It would be difficult for Coastal Zone Authorities (which are structured to reflect local needs) to interact with a central Area Coastal Zone Laboratory. Many Coastal Zone Authorities might be associated with an individual Area Coastal Zone Laboratory. Consequently, it would be difficult for that laboratory to respond effectively to the myriad problems which would be presented for solution by the many associated Coastal Zone Authorities. Difficulties of problem selections would be present with this plan.

Unique facilities would be available only at the Area Coastal Zone Laboratory and would not be duplicated at the local laboratories. As a result there would be some tendency toward maintaining the inferior status of some of the smaller local laboratories. This might occur as the result of good people leaving the local laboratories for the Area Coastal Zone Laboratories with their superior facilities.

3. Area and Regional Coastal Zone Laboratories

Concept

A two-tiered system composed of both Area and Regional Coastal Zone Laboratories would be established and structured to focus on coastal zone and estuarine needs at both an area and a regional level.

The regional laboratories would be given the responsibility of supplying the science and technology necessary for the management of the local coastal zones. Furthermore, solutions to offshore problems of purely local concern would be the responsibility of the Regional Coastal Zone Laboratories. Although only local problems will be examined, a multidisciplinary approach would be encouraged. Financing would originate at the Federal, State and, hopefully, local level.

In each major area, an Area Coastal Zone Laboratory would also be established. Here, offshore coastal and estuarine zone problems of either a more general or a more difficult nature would be examined. At the Area Coastal Zone Laboratory, unique and/or costly facilities would be housed which would be available to scientists at all laboratories, including the private, the regional, and the subregional Coastal Zone laboratories. Federal block funding would be used for staff salaries as well as for providing and maintaining the unique facilities.

Advantages

The two-level approach to coastal zone research provides a plan which is most responsive to local needs, yet can also attend to national, more general, and less immediate (but important) coastal zone research needs. The interaction of the Coastal Zone Authorities with the Regional Coastal Zone Laboratories should be exceptionally strong, since the interests of both groups are identical and focused on the same geographic region. Hence, local problems should receive very rapid attention and subsequent action. A grass-roots interest in maintaining the vigor and strength of the regional laboratory would be likely, and State and local financing of research needs would probably result. There would probably be Congressional support for local laboratories of the sort described by this option, because the impact of a local laboratory, attending to local needs, would be directly felt by the local community.

Disadvantages

The primary disadvantage of this laboratory system would be its high cost. If an area and a regional laboratory were to be considered for each of the areas and regions described above, then up to a total of 37 laboratories could be designated (27 regional and 10 area laboratories). The cost of such an undertaking would be large, but a substantial amount already exists in present appropriations.

A second problem associated with this option is the assignment of local problem-solving as the appropriate research activity of the regional laboratories. Although this is a necessary aspect of all Coastal Zone laboratories, the lack of research program depth would be stifling to most good scientists. The initiative to develop and expand research programs would be lacking, since, as the program attained depth and scope, it would be diverted to the attention of the larger Regional Coastal Zone Laboratories.

In addition, the more unique and, most likely, the more sophisticated laboratory facilities would exist for the most part at the Area Coastal Zone Laboratories. Such an attraction, coupled with the lesser program scope at the regional laboratories, could make it difficult to hold the better scientists at the regional laboratories. Hence, some regional laboratories would never be truly much more than marginal operations.

C. Other Options

There are, of course, a significant number of variations to either of these two options, with attendant advantages and disadvantages. These would include such procedures as the division of the research of the United States into four (NE, NW, SE, SW) or perhaps only two (Atlantic and Pacific) coastal regions with an equal number of central regional laboratories. Another possible procedure would be to select from each area the most outstanding Coastal Zone laboratory for designation as the central area laboratory. This would make unnecessary the construction of a new laboratory, but it would necessitate the development of criteria for the selection of such lead laboratories. Because of the diverse nature of activity being carried out at the local laboratories, such a table of criteria would be extremely difficult to generate.

CHAPTER 2

DISCUSSION OF UNIVERSITY/NATIONAL LABORATORIES

I. INTRODUCTION

A. General Background Considerations

The Commission made the following recommendations:

- The present variety of institutional arrangements for the development and support of oceanography is good and should be nurtured. Furthermore, as the horizons of oceanography continue to expand, new institutional arrangements can be encouraged.
- A small group of institutions, which should include but not be restricted to the acknowledged leaders, should be designated as "University/National laboratories." They should be distributed geographically to cover different parts of the ocean and should be provided with adequate facilities for undertaking local deep-ocean programs and basic sciences. Facilities should be made available to scientists at other universities and Federal laboratories for related basic science activity. University/National laboratories should be accorded adequate institutional support for maintenance and operations, and in turn they should commit themselves and their facilities to serve the needs of scientific groups affiliated with other institutions. Such an institutional arrangement will insure that the Nation's leading oceanographic institutions will be provided adequate resources and support to insure their continued health and vigor.

A survey shows that most Federal agencies and non-Federal institutions concur at least in principle with these recommendations. Unfortunately, the Commission's discussion of the University/National laboratories is somewhat imprecise. Although it is implicit in the report that the proposed National oceanographic laboratories would be modeled on the National laboratories run by the Atomic Energy Commission, a number of questions remain to be resolved.

- The Commission report did not explain or define the roles, responsibilities, and missions of a University/National oceanographic laboratory.
- The method of operation of such an institution was not explained nor were the obligations of the Federal government defined. In other words, the question of whether or not the Federal government would fund one or more of the following: ships, facilities, overhead, personnel, new buildings, individual programs, or specific investigators was not addressed.
- The process of review, evaluation, and coordination of operations of University/National laboratories was not defined nor was there any

discussion of the appropriate size or number of University/National oceanographic laboratories.

- Although it was recommended that the University/National laboratories should be distributed geographically, very little rationale for this recommendation was given other than to state that the different institutions would be able to cover different parts of the ocean. The implicit presumption exists that individual National laboratories would be given a franchise to cover certain areas of the ocean.
- The question of the requirements for designation and the method of selection of an institution as a University/National laboratory was not covered by the report.
- A review of present institutions which might reasonably be considered as candidates for designation to the University/National laboratory status indicates that some of these are private universities, some are State-run institutions, and one or more are independent corporations. The legal problems that would be involved in such a designation has not been addressed. Questions of a change being required in the institutions' charters, enabling legislation, or terms of incorporation were not reviewed by the Commission.
- The Commission report did not address the question as to how the funding level of University/National laboratories would be reviewed, in order to justify to Congress the size, scope, and uniqueness of programs in the proposed National Laboratories.

While the difficulties alluded to in the foregoing paragraphs are very real and must be resolved before a National oceanographic laboratory system can evolve, the concept of National laboratories is indeed reasonably attractive. We believe that the Commission's recommendations should be construed to mean that the combined facility resources of our major oceanographic institutions must be considered a national resource. If our Nation is to develop a vigorous commitment to maritime affairs, then we must recognize that our major oceanographic institutions will require a coherent program for the development of competent staffs and facilities. These must be maintained at appropriate support levels so that the expensive and relatively unique resources of these institutions may be used by all American scientists of acceptable credentials regardless of affiliation.

The meaning of the term "University/National laboratory" was not defined by the Commission; several National laboratories do exist which might serve as reasonable models. Of particular interest would be the operation of the National Observatory at Kitt Peak, the National Radio Observatory at Green Bank, the National Magnet Laboratory at MIT, and the Brookhaven National Laboratory. Fundamentally, a National laboratory is an organization which has certain costly facilities that are either unique or are not generally available elsewhere in the country. For example, there are relatively few 300-foot radio telescopes in the United States. It is clear that, unless a 300-foot dish was constructed for the narrow goals of a mission-oriented agency, the institution controlling this facility would have to make it available to competent scientists throughout the country.

The situation in oceanography is somewhat different from the situation at places such as Brookhaven, Oak Ridge, Kitt Peak, or Green Bank. There are a large number of oceanographic institutions in the United States. These vary in

number, size, and in staff levels from very tiny operations to reasonably large-size laboratories, such as Scripps or Woods Hole. Almost every oceanographic laboratory has a number of facilities which are common to all oceanographic laboratories. Most oceanographic laboratories have: (a) one or more sea-going vessels; (b) a staff to handle the maintenance, engineering and logistics associated with such vessels; (c) terminal facilities (docks, warehouses, etc.) to support the operations of sea-going vessels; (d) digital computers; (e) calibration and test facilities for equipment routinely used at sea; and (f) machine shops and other service groups to maintain, repair, and ready equipment for deployment in oceanographic research. No oceanographic laboratory has a facility that has the relative or absolute uniqueness of a large radio telescope or of a 30-BeV accelerator.

Clearly, the uniqueness of facilities cannot form a basis for the establishment of any individual National oceanographic laboratory. Nonetheless, the Panel feels that a number of considerations obtain which militate in favor of the establishment of some system displaying broad and comprehensive support of the Nation's oceanographic research community. The factors which dictate the need for some form of National oceanographic laboratory system are the following:

- A mechanism must be devised to allow for the orderly development and general sharing of oceanographic facilities which will become sufficiently expensive in the future so as to preclude their replication at every existing oceanographic laboratory.
- While American oceanographic institutions have shown a commendable ability to form consortia to undertake large-scale research programs, most of the present oceanographic institutions do not individually have sufficient depth of engineering talent, managerial skill, or scientific background to undertake some of the larger and more imaginative tasks which we hope will propel our nation into the forefront of oceanographic research and accomplishment.
- A system must be developed which will permit orderly growth in times of budget expansion and sensible and effective retrenchment in times of budget stringency. The present system with its multiplicity of oceanographic laboratories requires that proportionate shares of budget cuts be absorbed by all institutions. This tends to have a deleterious effect on the smaller institutions and does not leave the larger institutions with an efficient cushion to continue an effective program. If a National laboratory system existed, then overall facility planning and budgeting would allow for the maintenance of sufficient facilities to handle the minimum needs of competent workers in the field.
- Under the present system the more expensive facilities of oceanographic institutions are largely supported by imposing an overhead tax on funds which support individual research programs. The reckoning of this tax is a complicated procedure and creates considerable difficulty and inflexibility in the operation and provision of the routine personnel and support costs of our oceanographic laboratories.

B. Definition, Roles, and Responsibilities of a University/National Laboratory

The Panel would propose the acceptance of the following definition of a University/National oceanographic laboratory:

- A University/National laboratory is a Federally funded laboratory complex whose major responsibility is to carry out research and development oriented towards scientific goals of national importance. It further has the duty of designing, operating, and providing to the American scientific community unique and/or expensive facilities for carrying out oceanic research. In addition, it is a center where basic and applied research and exploratory development can be carried out on a continuing basis using a multidisciplinary approach.

The Panel construes the foregoing definition to imply that a University/National oceanographic laboratory would:

- Provide national leadership in large-scale efforts in marine science that require major facilities, equipment, and staff. This objective will be served by the laboratories' encouragement and by the fostering of long-term, large-scale scientific and technological programs that are necessarily expensive and by the provision of management of facilities for their accomplishment.
- Help assure that the marine manpower needs of the United States are met by providing graduate, postdoctoral, and continuing education for marine scientists and engineers.
- Insure that marine engineering and technology are based on good science, and that sound engineering and technological support are used in the advancement of marine science.
- Encourage and fund exploratory research and development in marine science and engineering and supply an environment in which new ideas may be conceived, supported in their infancy, and developed into working models.
- Maintain an effective position of the United States for advancing and cooperating in the international aspects of marine science and technology.
- Not be or become routine operational agencies, for the collection of synoptic oceanographic and meteorological data, but, on the other hand, work closely with agencies, such as the Navy Oceanographic Office, ESSA, the Bureau of Commercial Fisheries, the U.S. Geological Survey, and the U.S. Coast Guard, which have some surveying missions and, where appropriate, serve as managers for large, cooperative but short-term research projects, such as JOIDES.
- Coordinate the assignment and scheduling of facilities, on the basis of the merit and ability of investigators, or teams of investigators.
- Insure the just treatment of all potential users, including members of Federal laboratories and industry.

Based on the experience of existing National laboratories, it is clear that National laboratories may be administered in a variety of ways. Successful National laboratories have been operated by consortia of universities, by nonprofit corporations, by individual universities, and by the U.S. Government as either in-house laboratories or quasi-public corporations. Clearly, National laboratories do not, by definition, have to be a part of a university. The important characteristic of a National laboratory should be the existence of sufficient flexibility of operation and intellectual scope to allow a comprehensive interaction with all Federal, State, academic, and industrial components of the oceanic community.

C. Problems Associated with the Present Methods for Supporting Oceanographic Institutions

While American oceanographic institutions can boast an impressive record of scientific accomplishment, the Panel believes that this record was developed in spite of the present arrangements for institutional support rather than because of it. Support for oceanographic institutions has included a mix of sponsorship by the Office of Naval Research, the National Science Foundation, the Atomic Energy Commission, and several other Federal and non-Federal sources. There are certain weaknesses in the present multiple-agency funding that can be summarized as follows:

- The stability of program support depends on the funding priorities, or problems, of several different funding agencies.
- Program directors must coordinate activities and funding requirements with several different agencies with varying degrees of interest.
- Each Federal agency has its own administrative guidelines which make uniform handling of purchases, appointment of personnel, and consistent recovery of indirect costs impractical.
- Block funding for the support of vessel costs is hampered under conditions where each agency feels the need to furnish exactly its share of such costs.

As a consequence of these weaknesses, our oceanographic laboratories have difficulty undertaking long-range coherent research projects of importance to our national oceanographic effort. This difficulty is directly traceable to the lack of stability of program support on a long-term basis.

Cost of operations tends to increase because of the lack of uniform administrative regulations and reporting requirements of various Federally supported accounts.

Finally, because of the complex problems involved in acquiring sponsorship, a considerable amount of scientific time and effort is pre-empted. Given more stable institutional support, this scientific talent could be applied more effectively to scientific problems.

D. Criteria and Considerations Relative to the Selection of University/National Laboratories

The designation of certain oceanographic laboratories as University/National laboratories implies selective growth, funding, and expansion for the laboratories that are so designated. If it could be safely assumed that our National oceanographic budget would undergo a marked increase in future years, then this selective treatment could be viewed with equanimity, because the normal growth of the remaining laboratories would not be inhibited. However, if the future national oceanographic budget either grew slowly or remained relatively constant in absolute terms, then the preferential growth of University/National laboratories would occur at the expense of the remainder of the oceanographic community.

Concern over this problem led the Panel to circularize the following question to the directors of all major oceanographic laboratories in the United States:

- If your institution were not to be designated as a University/National laboratory, how would that affect it? Do you feel that the designation

of a selected group of laboratories would effectively inhibit the growth of those laboratories which were not so anointed? How would you view this situation from the standpoint of the overall health of the national oceanographic effort?

The response of the Division of Marine Resources, University of Washington, and the response of the College of Geosciences, Texas A&M University are particularly instructive. The University of Washington replied,

"...failure to attain U/N laboratory status would curtail but not prohibit our growth. If U/N laboratories are funded by redistribution of funds at existing funding levels, it would mean that any institution not so designated would suffer drastically as would the national oceanographic effort. The essential consideration is the establishment of the proper number of labs, which depends on funding strength, the national aims, and the strengthening of present repositories of excellence."

Texas A&M answered,

"It would seriously handicap not only the growth but the existence of my Institution, since the more outstanding staff members would leave. They would be attracted to the broader facilities, capabilities, missions, and potentialities of those institutions that would be designated as University/National laboratories. This would eventually result in the depletion of the staff to the point that eventually my Institution could not function effectively to solve important problems. Similar results would occur at other existing major institutions that would not be designated as University/National laboratories. Thus, the overall effect would be to restrict the total number of competent institutions to meet the increasing teaching and research requirements necessary to expand the oceanographic effort of the Nation, at a time when there is maximum need for these capabilities if our nation is to be able to develop at an accelerated rate the marine resources of the sea, for its benefit and that of the developing nations of the world."

Clearly, great care and discretion must be exercised in the selection of University/National laboratories. It is the strongly expressed view of the Panel that University/National laboratories, which are given selective growth and funding, should not be established unless the National oceanographic budget will permit both the continued growth of other oceanographic laboratories and the simultaneous development of strong National oceanographic centers.

While a number of options concerning the selection of University/National oceanographic laboratories are discussed below, the Panel believes that the selection of an institution should be based on consideration of the following factors:

- Excellence and breadth of its scientific capability.
- Existing size, strength, and experience in facilities management.
- The presence of a strong scientific community.
- Related activities of universities, government, and industry.

To these consideration, it should be added that the size of the selected institutions should be sufficient to encompass a wide diversity of research and teaching in marine and related atmospheric sciences. Thought should be given to a spread of geographic locations in

order to have a good coverage of oceans and climates. Thus, the Atlantic and Pacific should be encompassed, as well as the tropics and the temperate zones. This might be accomplished with four continental laboratories - NE, SE, NW, and SW. Their location should, if possible, coincide with the location of Federal laboratories with related objectives. They should be well staffed and of appropriate size, and the program should not be an excuse for large expansion of an existing smaller laboratory or, for that matter, of a larger laboratory.

An additional criterion for selection should be a history of successful operation over a substantial period of years. In choosing institutions on the basis of critical mass and experience, Scripps, Woods Hole, and Lamont stand out from all others. On the basis of diversity or breadth of spectrum, Scripps and Woods Hole stand almost alone. On the basis of geographic distribution, the University of Miami is the appropriate SE location and is also the only suitable one in biogeographically subtropical waters. Scripps and Woods Hole fill the Pacific SW and Atlantic NE locations. The NW choice would probably be the University of Washington, with Oregon State a strong contender. On the basis of association with neighboring Federal agencies, Scripps and Miami stand out, with Oregon State and Washington following. At Miami, the Bureau of Commercial Fisheries and the ESSA labs will be immediately adjacent to each other. On the basis of an educational function, Rhode Island would, at present, lead Woods Hole, where graduate teaching is barely out of the planning stage.

The choice of institutions for designation as University/National laboratories will be a complex process. Whatever criteria are ultimately used as a basis of selection, it should be made clear that future designations of other institutions would not be foreclosed.

E. Administrative Factors

1. Models for Support and Operation of National Laboratories

a. Some Characteristics of NASA funding

Funds for NASA are appropriated under these categories: Research and Development, Construction of Facilities, and Research and Program Management (which until recently was called Administrative Operations). Within each of these categories, the amount appropriated is specified for each of six program activities, and, in some cases, up to four subactivities. The median line-item in the Research and Development category is \$135,000,000 and in the Research and Program Management Category is \$67,000,000. The Research and Program Management Category covers salaries and other base expenses (power, computers, etc.) at the Federal laboratories operated by NASA.

This system of funding for salaries and certain other expenses at laboratories can be thought of as a type of block funding. It is presented, and defended however, primarily in terms of the program activities (e.g. manned space flight) rather than in terms of object classification. Some people feel that funds for Research and Program Management have proved especially vulnerable in the budgetary process and that this has led to a somewhat awkward mismatch in the categories of funds available to the laboratories. The older title (Administrative Operations) was sometimes misinterpreted to indicate an administrative overhead account. Use of this special category of funds appears to be grounded in the assignment to the laboratories of major out-of-house program management responsibilities.

b. Some Characteristics of AEC Funding

Funds for AEC are appropriated under two categories: Operating Expenses and Plant and Capital Equipment. The Operating Expense category is split among something over 30 program activities and subactivities (e.g., physical research - low energy physics) with the median line item being \$30,000,000. All major AEC laboratories are operated by contractors such as universities or industrial firms. At AEC Headquarters the offices concerned with particular activities, allocate part of the available funds among the various laboratories and, in many cases, reserve part for contracts with individual investigators at universities and elsewhere. At the beginning of each fiscal year the laboratories each receive a "financial plan" showing the amount they can spend within each activity and subactivity. Major responsibility for project selection and review is ordinarily delegated to the laboratory, so that "financial plans" reflect, especially regarding basic research, the suggestions of the laboratory scaled down in accordance with the current state of the fiscal climate.

In addition, the laboratories can seek support from other agencies. AEC approval is required, and the fund transfers are handled by interagency agreements. In practice these steps have not appeared to constrain work for other agencies.

c. A Joint AEC-NASA Office

The Space Nuclear Propulsion Office is a program office staffed jointly by AEC and NASA - an arrangement apparently unique within the Federal Government, but one which the participants feel has been fully successful. The integration is sufficiently close that the co-workers, on occasion, lose track of who is working for whom. The R and D management aspect of the operation has proceeded much more smoothly than seems likely with more traditional arrangements. On the other hand, some parts of the administrative workload are about twice as heavy as would be the case under single agency management. Separate budgets and budget justifications are prepared for the separate segments of the program for which AEC and NASA take fiscal responsibility. Numerous Congressional hearings must be prepared for and attended, and the budget faces double jeopardy. Two sets of procedures must be kept and applied in a variety of administrative and personnel matters.

d. Some Characteristics of NSF Funding

Except for the small Special Foreign Currency Program, the entire NSF appropriation is categorized as Salaries and Expenses. The activities and subactivities for which amounts are specified in the appropriation include: scientific research project support, specialized research facilities and equipment, National research centers, a National sea grant program, and institutional support for science.

The pattern of support for the National Center for Atmospheric Research seems particularly noteworthy. NCAR was founded in 1960 and is operated by the University Corporation for Atmospheric Research (UCAR), a consortium of 27 universities. The present laboratory complex in Colorado is NSF-owned, and the laboratory has 500 staff members including about 100 at the Ph.D. level. NSF has been providing about \$11 million annually for its operation. The contract between NSF and UCAR "is designed to give UCAR the scientific and managerial initiative essential to NCAR's task....At the same time, the contract contains requirements for Foundation review and approval which assure that the Foundation can exercise its sponsorship responsibility." NCAR conducts its own research program, serves as a focus for planning joint ventures, and makes its facilities available to outside investigators.

e. Characteristics of Laboratory Funding under a Naval Industrial Fund Plan (Naval Research Laboratory)

The Naval Research Laboratory operates on the Naval Industrial Fund (NIF) plan. As such, it is effectively a nonprofit, government-run corporation which exists for the purpose of doing research. Its parent agency, the Office of Naval Research, provides approximately one-third of the funds (32 million dollars) to carry out a program of basic research and exploratory development. The funds for basic research from the Office of Naval Research constitute approximately 22 to 23 million dollars and are used to pay scientific salaries and the cost of operating certain facilities, such as radio telescopes, oceanographic research vessels, cyclotrons, nuclear reactors, and special computers. The remaining two-thirds of NRL's funding comes from other Navy activities and other sections of the Government. The Naval Research Laboratory can accept funds and project sponsorship from almost any agency of the United States Government. Actually approximately one-third of its programs are sponsored by agencies outside of the Department of the Navy. Approximately 15 percent of the total funds of the Laboratory is supplied by agencies entirely outside the Department of Defense.

Internally, an overhead rate is established which is used to support shops, libraries, and the administrative support necessary to run a laboratory. Computation of overhead charges is based on the number of hours worked by direct-charge employees involved in any given program. Funds for the construction of facilities come as part of the total military construction appropriation that is appropriated directly by Congress.

The NRL model, while it has its drawbacks, has proven to be very successful and offers a great deal of flexibility in operation. The performance of the Laboratory is reviewed after the fact. Program proposals are normally written and reviewed by the Laboratory internal management. The Laboratory's achievements are then reviewed after the work has been completed.

Because only one-third of the funds comes from the parent agency, the remaining funds must be made up through research undertaken as the result of agreements with various sponsors in the Navy and in the remainder of the U.S. Government. Since no organization in the Government is obligated to contract with NRL for research funding, the Laboratory must function on a competitive basis with university, in-house, and industrial laboratories. This competition has proven to be a healthy stimulus and a source of much relevant work usefully performed for various sponsoring agencies.

f. Relevance to Marine Laboratories in the NOAA Case

The three categories of appropriations employed by NASA appear embedded in the use of employees at Federal laboratories for program management at out-of-house locations. Such a model seems inappropriate for a marine agency in which a major part of the laboratory structure might be largely based on the development of existing non-Federal laboratories. Even though the NASA model might not apply very directly, it would certainly be possible to develop a funding scheme in which some monies were earmarked for "base" or "block" support. Such a scheme is bound to run into problems of mismatch. In addition, such budgets can be more difficult to defend in convincing fashion.

Some problems of mismatch crop up with the split between operating and capital equipment expenses used by the AEC. The notion of subdividing a budget according to classes of closely related objectives seems an eminently sensible and workable one. Such schemes of subdivision seem preferable in general to schemes based in whole or in part on classes of expenses. The NSF appropriation appears to be broken down into reasonably coherent program activities and to be free of special expense categories. NSF may provide the best model to advocate for construction of the budget of a new agency.

g. Relevance to Marine Laboratories in the Non-NOAA Case

For the purposes of comment, it is suggested that NSF should be assigned principal responsibility for university-related marine laboratories. It appears that NSF, given the money, could provide facilities support and institutional support programs.

It is the strongly expressed view of the Panel that whatever model is followed for funding the National oceanographic laboratories, there must be one agency within the Government that has the mission of acting as a financial sponsor for the National laboratories. If there is not a single agency entrusted to worry about the current budgets and long-term development of these National laboratories, then the laboratories will be considerably worse off than they are at present. When an organization is in a sense a "National orphan," and when there is no central agency within the Government to which it may turn, then it must ultimately wither and die.

2. Areas of Federal Support

Development of a National oceanographic laboratory will require modifications in the existing relationships between the Federal Government and the participating institutions. Planning for the establishment of such a laboratory will require a major investment in scientific and technical talent and other local resources by the selected institution. Program objectives must be defined cooperatively and the supporting facilities planned and acquired. The organization must be carefully constructed to assure accomplishment of scientific objectives and the proper participation of many institutions and agencies.

In the definition and development phase, the Federal sponsor must work closely with the institution to develop a jointly acceptable master plan. Following the joint acceptance of this plan, support must be assured at an adequate level on a continuing basis. Institutional support, at least in major program areas, is necessary for proper local management. A review process of programs and project scheduling must be cooperatively established which will assure the maintenance of a high level of scientific productivity commensurate with the achievement of national goals.

Clearly the major funds for ships, facilities, overhead, personnel and new buildings must be supplied from Federal sources if the program is to be more than a paper fantasy. Individual programs and specific investigators will be sponsored by Federal and non-Federal agencies as the result of review and negotiations between the laboratory and the agencies on the desirability of pursuing an individual research program. However, it is important for efficient management that as much flexibility as possible be given to the University/National laboratory management. Therefore, institutional or block funding of major program areas must be provided with whatever review is necessary on the basis of the performance of accepted objectives. It would be desirable to have this funding committed over a long period of time. This approach differs from present support patterns which are short-term and limited in the scope of objectives.

The funding pattern for a University/National laboratory would differ from the present pattern of Federal sponsorship in that at least the following should be line items of the budget and block funded as laboratory support: fleet procurement and operations; facilities procurement and operations; common use equipment and supplies; support and technical personnel; salaries of senior technical personnel; administrative and managerial functions; and "seed" research funds, based on some small percentage of overall budget, to be devoted to support innovative projects of exceptional scientific merit.

The percentage of total funds available to a National oceanographic laboratory that come in support of the foregoing items should probably not exceed 50% of the institutional budget. The remainder of the funds required to run the laboratory should reflect Federal and non-Federal support for specific research projects.

3. Review Procedures

The establishment of National oceanographic laboratories will require a well-defined system of a review, evaluation, and coordination. The Panel expects that the scientific programs of the laboratories would be reviewed by panels of competent scientists chosen by agreement between the sponsor and the laboratory. Although there would be continuous administrative and budgetary review, all the review processes should be designed to promote the long-term funding of continuing operations and to increase the efficiency of the proposal and review processes. Coordination of all University/National laboratories will be required to prevent undesirable overlap of programs and operations, although some replication is frequently good and necessary. We would expect each of the laboratories to be represented on a coordinating body. Evaluation and coordination of major objectives should be on a long-term basis and will represent the consensus of the members of the scientific community and the Federal sponsor who will participate in the programs.

The review process used at Argonne National Laboratory might well serve as a model that could be emulated at the National oceanographic laboratories:

- Review of the operation of Argonne National Laboratory may be divided into the internal and external mechanisms.
- The internal mechanisms are related to the organizational structure of Argonne. The Laboratory Director has, in line positions, Associate Laboratory Directors for the major categories of work. These are Engineering, High Energy Physics, Physical and Biological Research, and Educational Affairs. The Directors of the Scientific and Technical divisions of the Laboratory report to the first three of these Associate Directors.
- Internal review of the technical program of the Laboratory is carried out by successive reviews by the Division Directors, the Associate Laboratory Directors, and the Laboratory Director and his staff. Division Directors (frequently with the advice and consultation of their senior staff) conduct in-depth reviews of on-going programs as well as proposals for new research. This occurs at least twice per year during budget preparations, and is followed by reviews by the appropriate Associate Laboratory Director. The Laboratory Director and his staff may participate or may conduct independent reviews. In any case, at least two and occasionally three independent reviews are conducted at least twice a year.
- External reviews of the Laboratory's program are carried out by review committees. These committees report to the President of The University of Chicago and to the President of Argonne Universities Association. The members of these review committees are drawn from the university community, industry, and other National laboratories. They meet usually once a year and report on the quality of the scientific work of the unit under consideration.
- The Laboratory's operations other than the technical program are reviewed by the Technical Services Manager, the Business Manager, the Budget Manager, and the Laboratory Director and his staff. Such reviews are carried out at least twice a year in connection with budget preparations and in special situations as required.

Although the precise amount varies from Institution to Institution, at present approximately 75 to 85 percent of the total operation in the marine sciences is supported by

Federal funds and is already subject to annual review. Thus, the oceanographic institutions have had considerable experience with detailed annual reviews.

The Panel believes that the traditional type of programmatic review would not be appropriate for National oceanographic laboratories. To the fullest extent possible the annual reviews of these laboratories should be administrative functions, specifically funded, with major reviews of a substantive nature relating to program content, undertaken at longer intervals.

4. Staff Levels

The Panel reviewed the growth projections of several major oceanographic laboratories to determine the budget requirements, the facility requirements, and the staff levels that would be needed for a National laboratory. It is clear that no uniquely appropriate size exists for such an organization. At any given time, its size will be a function of the objectives and goals of the work, the amount of funding available, and the availability of high-quality staff members.

The influence of the objectives of a National laboratory on its size can be illustrated by a comparison between existing laboratories. The Ames Laboratory, with a mission emphasizing fundamental materials research, has about 750 employees and an operating budget of about \$9,500,000 per year. On the other hand, the Argonne Laboratory, which has broadly defined responsibilities in reactor programs, in physical research, and in biological and medical research, employs about 5600 people and has an operating budget of \$100,000,000 per year. While other factors enter into the difference in size of the two laboratories, the goals and objectives are the most important. The influence of the amount of funding and the availability of staff on the size of a Laboratory needs no comment.

A detailed review of all of the laboratories which might reasonably be considered as candidates for designation as a National oceanographic laboratory indicate that on a National basis there is a need for a modest expansion and improvement in our pool of good sea-going scientists and technicians. In addition we need better supporting facilities and additional technical support personnel as well as better facilities to improve the quality of undergraduate experience and education in the marine sciences.

To redress these deficiencies and to incorporate within the National oceanographic laboratories all phases of marine science and engineering development, the Panel believes that a small but purposeful expansion in the staff levels is necessary. At present, none of the existing oceanographic institutions has sufficient size and depth to satisfy all of the requirements of a National laboratory. The deficiency is a matter of degree and it varies from institution to institution. Even the largest of our oceanographic institutions exhibit some shortcomings when viewed in the context of a National laboratory.

As an example, the resident scientific staff of the Woods Hole Oceanographic Institution is composed of 78 men and women: 22 senior scientists, 33 associate scientists, and 23 assistant scientists. The resident technical staff includes 17 research specialists and 54 research associates. These 149 resident staff members are supported by approximately 425 additional employees who are technicians, clerical workers, ships' crews, shop personnel, and others. The central themes guiding the research at WHOI include: physical oceanograph, geology and geophysics, chemistry, biology, and ocean engineering. In pursuit of these disciplines, the Institution is organized into five departments which have professional staffs that average about 30 people. The number of senior scientists in any department generally is not in excess of five or six people.

Admittedly the quality and productivity of a group cannot be measured in purely numerical terms. Certainly the professional productivity and influence of WHOI far

exceeds what may be expected from an organization of its size. Nonetheless, it is clear from the limited numbers of professionals employed at WHOI, that there are significant limits both to the number of relevant scientific disciplines that are represented at the Institution and to the number of people available to work in any given discipline. For example, only a few people at WHOI pursue the crucial area of marine corrosion as their central professional orientation.

The foregoing comments are not intended to denigrate the scale of effort at Woods Hole. Rather, they are meant to illustrate the premise that even some of our largest institutions are, in many respects, inadequately staffed to assume the roles and responsibilities of a National laboratory as envisaged herein.

While the Panel does not and cannot presume to describe staffing levels for National laboratories, we estimate, on the basis of extended discussion with various laboratory directors, that the professional and technical staff of a National oceanographic laboratory should number between 400 and 500 people. This number may be arrived at in a variety of ways. For example, a typical research division at a major National or corporate laboratory (Argonne, NRL, NBS, BTL, etc.) is usually organized about a group of approximately 50 professionals who work with a central focus on one of the major scientific disciplines (metallurgy, reactor design, marine biology, etc.). A group of this size is able to work on a number of problems requiring expertise in one or more of the sub-disciplines within the major field of interest. It would appear desirable that a multidisciplinary National laboratory should be able to mount a critical level effort in eight or ten major oceanographic disciplines. Consequently, four to five hundred professionals with appropriate support would seem to be a reasonable staff level.

If WHOI were designated as a National laboratory, its professional staff would have to be expanded by a factor of about 2-1/2. This expansion would, of necessity, be accompanied by some expansion of the present support staff of 425 people. Fortunately, after a certain level of support has been reached, the support staff does not increase linearly with the scientific and technical staff (for example, the number of librarians and guards in a laboratory increases rather slowly as the professional staff increases).

The staff level at Scripps is more nearly of a size to allow it to assume the role of a National laboratory. The total staff at Scripps numbers approximately 225 professionals supported by a nonacademic staff of about 750 people. This effort is supplemented by a group of about 125 matriculated graduate students pursuing advanced degrees. If one includes these graduate students, then by the considerations outlined above, an increase of only 50 to 150 professionals would be required for Scripps to reach a professional staff level that is appropriate for a National oceanographic laboratory.

The other oceanographic laboratories which might be considered for designation as National oceanographic laboratories would have to undergo a commensurate growth in their full-time professional staff. In general, no laboratory should be considered for such designation if it would require a staff expansion by a factor of 4 or 5 to reach the professional staff size discussed. The rationale for this view is related to the rates of growth that can be reasonably absorbed by an institution. To double a staff within 10 years, an annual growth rate of about 7 percent would be required. A time scale of 10 years has been arbitrarily chosen as the appropriate time required for a small oceanographic laboratory to develop into a National laboratory. To increase the size of a staff by a factor of 5 within 10 years, an annual growth rate of about 17-1/2 percent would be required. When consideration is given to the fact that large laboratories typically undergo staff attritions of about 5 to 6 percent per year, rather high levels of recruitment would be required. There appears to be a limit to the rate of growth that can be sustained without accepting a degradation in the quality of the staff or the

acceptance of some rather disruptive growing pains. Laboratories probably should not attempt to sustain overall rates of growth which require the assimilation of new staff members at rates exceeding 15 percent per year.

5. Budget Requirements

It is difficult to project the budget requirements of a National oceanographic laboratory with any accuracy. While precise estimates are impossible to supply, the budgetary requirements for a National oceanographic laboratory have been reviewed by all of the oceanographic laboratories which might be considered as candidates for selection. A detailed publication of these figures would not serve any useful purpose, since these projections are based on a large number of assumptions which may not be realized. A review of these projections, taken in conjunction with data related to the operating expenses of existing national laboratories, allows a rough projection of operating budgets.

The budgetary cost of supporting a member of the professional staff of a laboratory normally runs between \$35,000 and \$40,000 per year. The variation in cost is a statistical one, representing minor fluctuations in the cost of research and in the accounting methods used to decide which direct charge and which support employees are figured into the computation. By a calculation of this type, one finds that a laboratory with a 400-man professional staff (which the Panel feels is representative of a desirable size for a National Laboratory), would require an annual operating budget of 14 to 16 million dollars per annum for routine salary-related expenses. This budget would only cover salary, support personnel costs, and routine minor procurements. Major capital investments and the cost of operating and maintaining large facilities, such as oceanographic vessels and computers, would not be included in this total. The basic annual operating cost of 14 to 16 million dollars would be supplemented by the cost of the capital investment needed to buy special purpose major procurements. In a well run laboratory, special purpose major procurements (\$40,000 tape recorders, mass spectrometers, specially designed buoys, etc.), should amount to approximately 10 to 15 percent of the routine or fixed salary-related budgets. With a laboratory having a 400-man professional staff, the routine investment in major procurements should amount to about 2 million dollars per annum. Thus, the salary-related costs and the capital investment for major procurements would amount to approximately 16 to 18 million dollars per year.

These costs would be supplemented by the costs of computer centers, operating ships, aircraft, other special facilities. A computer center for a laboratory of the size envisioned would cost between 1/2 and 1 million dollars per annum. Ship costs are a function of the number and size of the ships in the fleet. Depending on where the salaries for the crew appear in the budget, it might reasonably be considered that ship operating maintenance costs for a major oceanographic laboratory would amount to between 5 to 8 million dollars per year.

Summing up, we find that a major National oceanographic laboratory should cost approximately 20 to 25 million dollars to operate. This figure does not include the costs of funding new vessels or new buildings. The costs related here should be contrasted with the present level of operations. Roughly speaking, the 1969 budget levels of the major Laboratories are: Scripps, 12 million dollars; Woods Hole, 9.5 million dollars; University of Miami, 6.3 million dollars; Lamont, 5 million dollars; Oregon State, 2.7 million dollars; and University of Washington, 2.3 million dollars. None of the foregoing figures are deemed to be precise in that they have not been reviewed for uniformity of accounting procedures or subjected to a standard criteria for intramural and extramural expenditures.

As pointed out, the Panel does not believe that the Federal Government must supply all of the funds outlined above under a National oceanographic laboratory program. The funds required from the Federal Government under the National oceanographic laboratory

program would be primarily for core support and would not exceed 50 to 55 percent of the total institutional requirements. Nonetheless, Federal agency funds would constitute the remaining funding. The Panel believes that funds above and beyond those necessary for core or institutional support as defined above should continue to come on the basis of mutual agreements between the National oceanographic institutions and sponsoring agencies which are interested in specific research programs. At present, Federal funds for oceanography probably constitute 85 to 95 percent of the total monies expended in the field.

Assuming that the ratio of 50 to 55 percent of total budget is accepted and implemented under the National oceanographic laboratory program, then the support program will require 10 to 12-1/2 million dollars per year per laboratory. If four laboratories are selected to be National oceanographic laboratories, then the annual budget for core support and fixed operating expenses will amount to approximately 50 million dollars per year.

6. Facility Needs

The results of a Panel survey indicate that the available facilities at all oceanographic laboratories are inadequate to the needs of a National oceanographic laboratory. Most of the Oceanographic laboratories have made an inventory of their present facilities and have submitted an appraisal of their long-term needs to the Panel.

While it would not be particularly useful to include lists of facility needs in this report, it is instructive to consider, in general terms, the anticipated needs of three institutions - Woods Hole, Scripps, and the University of Washington. These needs are discussed to illustrate the diversity of the required facilities and the magnitude and types of Federal support that might be required. We wish to reiterate that we are speaking in general terms and that our projections do not represent the official views of the institutions concerned.

The present facilities of the Scripps Institution of Oceanography were deemed to be only minimally adequate for the level of operations that took place in 1966 and 1967. No new University-funded space has been provided since the transfer of Revelle College activities to the upper campus in 1964. This event was prior to the expansion associated with the Deep Sea Drilling and North Pacific Buoy projects. Future space requirements are necessarily keyed to projections of overall staff size. In view of the heterogeneous nature of the space presently available at Scripps (scientific collection storage, classrooms, shops, offices, warehousing, laboratories, special facilities, etc.), it can only be assumed that the present overall mix of facilities will obtain in the future. Also, it is probably safe to assume that the space factors currently required to support an individual staff member will represent the minimal level of facility support needed for an expanded program in the future.

It appears that Scripps could usefully avail itself, within the next 5 or 6 years, of approximately eight buildings, which would represent an additional useful space equivalent to 250,000 square feet. These facilities would include a new library building, a research support shop, equipment warehouses, an oceanographic collection building, and some general-purpose laboratories. At present construction prices for laboratory-type structures, these additional facilities would cost approximately 20 million dollars. The Federal contribution to this building program cannot be defined precisely. However, it may reasonably be estimated that half of the required funds for new facility construction would have to be supplied by the Federal government. Thus, establishing Scripps as a National Oceanographic Laboratory would require approximately 10 million dollars worth of construction funds within the next 5 to 6 years.

In addition to an expansion of the shore-based establishment, the Scripps ocean-going fleet would require a selected expansion. Some of its older ships should be replaced, and some new ships should be added to supplement the size of the fleet. The Horizon should

be replaced in the early 1970s by a vessel in the 950 to 1000 ton class. In addition, a biological training ship and possibly a high performance AGOR will probably be required in the late 1970s. During the next 10 years, the other ships in the Scripps fleet will probably be adequate for the normal institutional usages or for any anticipated expansion of its activities.

The present shore-based facilities of Woods Hole Oceanographic Institution are totally inadequate both for the present staff level and for the expanded levels that would be required if Woods Hole were to be designated as a National oceanographic laboratory. The space available per scientific investigator at Woods Hole is approximately half the amount that is commonly accepted for planning purposes at major National laboratories. The newest institutional building is the Marine Services Building, located on the newly enlarged pier. Two other laboratories, the Bigelow Building and the Laboratory of Oceanography, are adjacent to the pier. The Marine Sciences Building, which was designed primarily for biology and chemistry, is physically separated from the other buildings but is still within the village of Woods Hole.

The Institution has additional land available to it. Looking to the future, the Institution has purchased a 140-acre site in Quisset. This site, which is intended for a future campus, is about 1/2 mile from the village campus in Woods Hole. It is intended that, in the future, the village campus will concentrate on matters related to research and education. If Woods Hole were to be designated as a National oceanographic laboratory, then the satellite activities (particularly those of an applied nature) would be located on the outer campus at Quisset. The first use of the Quisset campus will be for a program in aquaculture.

At present, Woods Hole has a serious brick-and-mortar problem. There is a need to build a new laboratory building with 120,000 square feet of floor space. It is anticipated that this laboratory will be built on the land near Challenger House. This construction would represent only 20 percent of the ultimate needs of the Institution. Thus, it appears that, if the Institution were to expand to the size that is believed to be required for a National Laboratory, approximately 600,000 square feet of building would be required. Construction of this magnitude would cost approximately 50 million dollars.

Because Woods Hole is a private corporation, it would have some difficulty in obtaining state funds for construction of facilities. Based on past experience, it is reasonable to assume that the required expansion of the physical plant at Woods Hole would require a substantial Federal contribution. For purposes of planning, it should be assumed that over the next 10 years the Federal government would have to invest approximately 40 million dollars to improve the shore-based facilities of this Institution if it is to play the desired role of a National oceanographic laboratory.

The sea-going facilities of the Woods Hole consist of four sea-going vessels and, assuming the successful refurbishment of the Alvin, two submersibles. With the exception of the Gosnold and the Chain, all of the surface ships are relatively modern. It is anticipated that by the late 1970s this fleet might have been augmented by one or more major research vessels and one or more exotic platforms or submersible vehicles. Given the available oceanographic vessels, only a relatively small incremental change would be required in the fleet size. The costs of these increments would not be trivial. Major research vessels, depending on size and complexity, represent an initial cost that may be in the range of 10 to 30 million dollars. With the completion of the new Marine Services Building, facilities for ship handling and services are adequate for foreseeable needs.

The facility requirements of the Division of Marine Resources of the University of Washington are of interest in that they typify the situation that exists in some of the more moderate sized oceanographic laboratories. A review of the anticipated needs of the

University of Washington indicate that a minimum of approximately 400,000 to 450,000 square feet of additional floor space would be required over the next 10 years. This construction would include a new research building designed primarily for chemical and experimental physical oceanography and a special purpose laboratory building for model studies that contains special environmental spaces and high pressure equipment. In addition, there is a need for many special facilities for technical services, these facilities including machine shops, a development laboratory for the design, construction, and evaluation of instruments, a calibration laboratory, an acoustics laboratory, a diving shop, a small boat maintenance shop, a woodworking shop, and an electronics shop.

The pattern of funding facility construction at the University of Washington would probably be similar to the funding pattern required for Scripps. Thus, the Federal contribution to the anticipated construction costs of about 35 million dollars would probably amount to 17 or 18 million dollars.

The fleet of the University of Washington would have to be expanded to include a new, large AGOR and a newly designed stable platform. In addition, it would appear prudent to procure a new research vessel of approximately 150 feet with replaceable modular laboratories to increase its versatility and to decrease the turnaround time. In addition to a new student training ship of approximately the same dimensions, one or two small submersibles, some aircraft support, and two to four somewhat specialized research vessels in the 65 to 85 foot category would also be required.

It is clear that any program for the development of University/National laboratories will require a considerable annual national investment in the new facilities. Although there is clearly a significant need to expand the sea-going fleet, the required facilities are mostly in the area of new laboratory facilities. For rough planning, it would appear that over the next 10 years an investment of 100 million dollars for shore-based facilities would be required to achieve the establishment of four properly staffed and equipped National laboratories. This sum would have to be supplemented by a 10-year investment of 150 to 200 million dollars for mobile ocean-going facilities.

7. Support Requirements for Oceanographic Laboratories not National Laboratories

As evidenced in many aspects of this report, the Panel was deeply concerned about the need to protect and maintain the operation of oceanographic laboratories that are not designated as National laboratories. The Panel specifically recommends an improved program for the support of the leading universities and private research institutions now engaged in oceanographic research and graduate training.

This program should incorporate the assignment of funding responsibility for all institutional support to one Federal agency (preferably NSF). The Panel construes the areas of institutional support to include the costs of ship operations and the costs of central computers, shop services, and other shared facilities and equipment. In addition, institutional support should cover the costs of a reasonable portion of supporting and overhead personnel, and it should provide a small allowance for general purpose research and training activities. This support should be provided in block form on the basis of negotiations following periodic institutional review. Funding in this block form would range from 40 to 60 percent of each institution's total annual budget. The balance would be derived from project support provided by the responsible agency, by other Federal sources, or by State and local sources, as appropriate.

The designated Federal agency should also be assigned responsibility for the provision of facilities to the community of competing institutions. Presumably, this responsibility would imply a coordination responsibility with any other agencies which may continue to provide support for certain facilities, such as ships and submersibles.

The Panel was not able to develop precise figures for the funds which would be required to support these institutions. Rather than attempt to publish a "wish list," it is sufficient to state that the funds which must be supplied will need to be sufficient to assure that the group of existing institutions are sustained at their present levels of operation and are permitted growth commensurate with their capabilities and performance. This means that facilities support must be provided to upgrade by replacement about two-thirds of the existing fleet of research vessels which this group now operates. It also means the upgrading of shore-based facilities which have been inadequately supported in recent fiscal years.

In general terms, the budget requirements may be divided into the three broad categories which consist of ship construction, shore facilities construction, and operational and institutional block support.

Ship Construction

Estimates for a 10-year program for the replacement of aging vessels, now making up approximately two-thirds of the collective university-private institution fleet, indicates that about 24 new vessels of varying size will be required. These estimates were recently developed jointly by the National Science Foundation and the Office of Naval Research. Prorated annually, the program might cost a total of approximately 15 million dollars per year.

Shore Facilities Construction

Estimates for a 10-year program to upgrade and expand moderately the laboratory and shore support facilities of the leading oceanographic institutions, other than those designated as National oceanographic laboratories, vary rather broadly. It is quite likely that 60 million dollars might be required over a 10-year period. Part of this sum would be met by matching grants from States and from private sources. Institutions would compete for funds on the basis of plans generated locally in accordance with demonstrated need. Evaluation procedures should follow the well-established patterns employed by NSF in its various facilities support programs. Prorated annually, this program might cost 6 million dollars per year but might begin at a lower level (say 4 million dollars) and increase yearly to meet increasing costs and growing needs.

Operational and Institutional Block Support

The full cost of ship operations for the university-private institution fleet now constitutes 20 to 25 percent of the annual operating budgets of these institutions. Using 14 million dollars as a base for Fiscal Year 1970 and assuming annual increments of between 5 and 10 percent annual costs for a nearly steady-state fleet, these costs may be expected to rise to 25 million dollars or more by 1980. Other block support for institutional costs will approximately equal ship operations support as institutional funding rises to an average 50-percent level. The latter, however, can begin at a substantially lower percentage and rise selectively at individual institutions in accordance with program performance, need, and other considerations.

II. AVAILABLE OPTIONS

If the U.S. Government accepts the view that strong Federal sponsorship of oceanographic research centers is necessary, then it is the view of the Panel that the following four options should be considered.

1. The U.S. Government could designate one or more existing oceanographic laboratories as National oceanographic laboratories. It could state that, as a matter of national

policy, the Federal government intended to undertake responsibility for all overhead, support, and facility costs. The growth of these National laboratories to some preassigned size could be sponsored selectively by the Federal government.

2. The U.S. Government could "Nationalize" the use of all oceanographic facilities for which it now provides predominant budgetary support. These facilities (predominantly ships) would be maintained and supported by a single Federal agency, and the services of these facilities would be made available to all competent oceanographers. The scheduling of these Nationalized facilities would be controlled by members of the oceanographic research community through the mechanism of appropriately established user committees. In addition to ship operation and support, the agency which was given responsibility for this task might supply other services, such as consolidated engineering, software development, and ship and exotic platform design.

3. The U.S. Government could encourage the formation of regional laboratory centers, which would be composed of consortia of all of the oceanographic laboratories in a given geographic region of the country. While the component members of these centers could maintain their institutional integrity and location, they would be encouraged to use the facilities of the regional centers and to consolidate their research programs with other members of the center.

4. The U.S. Government could accept present institutional forms, without sponsoring changes, and encourage the growth of oceanographic research and training by increasing the magnitude of funding and introducing more flexibility in the funding pattern. Under this option, the U.S. Government would block-fund facilities, their support, and their overhead costs at existing and/or evolving oceanographic laboratories and institutions.

The Panel has reviewed each of these options. All are rather difficult to implement and all of them are subject to many objections. The problem of converting a number of existing laboratories with a multiplicity of corporate forms into some variant of a National oceanographic system is bound to be extraordinarily difficult. The principal difficulty will be in establishing the criteria and rationale for the selection of any course of action. The definition of a National laboratory in the context of oceanographic research is not a simple problem. Mechanisms for providing budgetary support, providing program review, developing long-term planning, and determining appropriate level of effort would all have to be addressed. The problems of the Federal responsibilities towards laboratories which are not Federal institutions will have to be examined.

Philosophical questions of whether our nation is better off with an oceanographic effort that is spread out in many parts of the country and in many institutions, as opposed to being concentrated in a few well-funded laboratories, cannot be easily resolved one way or the other. While all of these questions must be addressed before a National laboratory system can be implemented, the Panel has reasonable confidence that these problems can be resolved. The issues which must be considered in choosing one of the foregoing options are sufficiently complex that these options cannot be accepted or rejected on the basis of short-term objections. Our goal must be the establishment of a system which will do the most to nurture and enhance the maritime capability of this nation. The advantages and disadvantages of the four options are discussed in the following subsections.

A. Option 1

1. Concept

Under option 1, one or more of the currently existing oceanographic institutions would be declared to be a National oceanographic laboratory. Where necessary, appropriate

enabling legislation or charter changes would be instituted. Once one of the existing laboratories had been declared a National oceanographic laboratory, its growth would be selectively encouraged in order to create an oceanographic center of critical size. It is envisaged that a National laboratory would be large enough to service the unusual and/or major facility needs of most oceanographers in the country. It would also be able to attract a significant fraction of the oceanographic research community and thus would be able to create an intellectual environment which would be hospitable to the concept of large-scale programs. Under this option, approximately four suboptions exist:

Suboption 1A. Proclaim only Woods Hole and Scripps to be National oceanographic laboratories.

Suboption 1B. Proclaim Woods Hole, Scripps, The University of Miami, and The University of Washington to be National oceanographic laboratories.

Suboption 1C. Proclaim the nations ten largest oceanographic institutes to be National oceanographic laboratories.

Suboption 1D. Proclaim four geographically separate Federal laboratories to be National oceanographic laboratories.

Suboption 1E. Any combination of options 1B and 1D.

2. Advantages

The advantage of pursuing this option, in any of the variants listed above, would be that a selective development of a major oceanographic laboratory could occur. If suboption 1A were followed, then we could look forward to the existence of a National oceanographic laboratory on both the Atlantic and Pacific coasts. As facilities were given selectively to these institutions by the Federal Government, these laboratories would take on more and more of the character of a National laboratory. Scientists from other oceanographic institutes would congregate at these centers, and one might hope that by this process an enhanced degree of vitality and programmatic synthesis would be achieved.

A certain degree of efficiency would be achieved as the need for replication of facilities decreased. Facilities such as large-scale digital computers, central library and data repositories, special physical models of various components of the ocean, exotic platforms, and major and minor research vessels would be available, along with their operational support groups. Other institutions would ultimately find it unnecessary to maintain these facilities separately. Further, by forcing investigators from other laboratories to use these facilities, one would insure a large degree of intellectual cross-fertilization. Both Scripps and Woods Hole traditionally have had strong and close association with university groups. By making the facilities of the National laboratory available, universities which do not have a sea-going oceanographic capability could be encouraged to develop curricula in oceanography without facing the expense of providing facilities.

Suboption 1B is in essence a variant of suboption 1A. However, rather than designating two laboratories, we would designate four laboratories as National oceanographic laboratories. This would have the advantage that there would be better regional distribution. One National laboratory would in essence be located at each corner of our country. Greater centralization on regional plans and programs could be achieved. If there were four National oceanographic laboratories and the Federal oceanographic budget were held at a fixed level, then the size of each of the laboratories would be only half the size of the national laboratories that would exist if there were only two laboratories so designated. With regard to university education and the training of future oceanographers, this option

is twice as attractive as suboption 1A; both Miami and the University of Washington are university-affiliated institutions.

Suboption 1C would consist of designating the nations ten largest oceanographic laboratories as National oceanographic laboratories. From time to time this number might be changed as a new Laboratory grew beyond a certain threshold or one of the existing Laboratories fell below some critical threshold of size and effectiveness. The advantage of this approach would be that a broad base of geographically distributed laboratories could be used. Sponsorship would be given to all ten organizations in an effort to avoid extreme centralization of our oceanographic research effort.

Again, for a fixed budget, each Laboratory could only grow to 1/5 the size that a national laboratory would grow if the number were limited to two. Nonetheless, by concentrating on ten major laboratories, some help could be given to the smaller laboratories in this group. Because of the greater geographical distribution of these ten laboratories, local investigators would not have to travel as far to make contact and use facilities.

Suboption 1D would be to use one or more of the laboratories that are already in the Federal laboratory system. The advantage of using existing Federal laboratories would be that these laboratories are already within the Federal structure and are more easily controlled and directed. A laboratory which is a component of the Federal Government must be intrinsically responsive to the stated aims of national policy. A Federal institution can be expanded to provide such services as are necessary to the National oceanographic community to encourage growth, to maintain engineering competence, and to provide for facilities in an orderly manner. In addition, many Federal laboratories have a commendable history of working with universities and in sharing facilities.

3. Disadvantages

The disadvantages of suboptions 1A, 1B, and 1C are reasonably numerous. The principle difficulty associated with suboption 1A would be the need to justify the selection of only two laboratories. However one might justify such a selection, opposition would develop from the laboratories which were not selected. The fear would undoubtedly be expressed that the selected laboratories would grow while the smaller laboratories not selected as National laboratories would wither and die. The wisdom of concentrating oceanographic research in two major centers is certainly open to some question. There is a National strength that comes through organizational diversity. Indeed, the argument can and has been made that one of the principle strengths of American oceanography is that many individual organizations exist and these are not bound up with the parochial views and vested interests of a few large organizations.

The same objection can be raised to suboption 1B. The designation of four laboratories is only slightly more liberal than the designation of two. Under such circumstances, the objection can be made that the designation of limited numbers of laboratories still will tend to rule out of all constructive future development the existing laboratories that are not annointed as National laboratories.

Suboption 1C would mean effectively no selective government policy on the creation of a National laboratory. Ten laboratories would be encouraged to grow. Presumably the funds which are likely to be available would be such that none of them could grow to a critical size so that they could become equivalent to an Argonne Laboratory, an Oak Ridge, or a Brookhaven. In addition, specialized and expensive facilities would have to be provided and replicated at ten institutions. The programs of each institution would have to be justified to Congress individually, and one would have to account for their number, programmatic uniqueness, and social utility. Unreasonable or nonproductive competition might develop among the ten national laboratories for budgetary support, new

facilities, and personnel ceilings if these were to be invoked. It is felt that this would eventually become an extremely untenable situation.

Suboption 1D involves the use of Federal laboratories to serve as National laboratories. A number of difficulties exist with such use of Federal laboratories. Federal laboratories tend to be subject to arbitrary ceiling and other operational constraints that limit their size. If not skilfully managed, a Federal Laboratory could become inflexible and inadequate in its relation with the American oceanographic research community. Despite these difficulties, a great deal of scientific attainment and stature has been achieved by certain Federal laboratories. The principal difficulty with this option is that the existing Federal oceanographic laboratories do not have the present scientific stature, manpower, or reputation to serve as a reasonable nucleation center for National oceanographic laboratories. Thus, unless DOD laboratories were detached from the parent organization, personnel would have to be recruited almost ab initio and new Federal organizations would have to be formed. The efficacy of this course of action would be subject to question when existing nonprofit institutions were available for the purpose in the private sector of our society.

B. Option 2

1. Concept

Under option 2, it is proposed that all oceanographic vessels, exotic platforms, and specialized facilities which have been paid for by the U.S. Government (or whose operation is supported by more than 80 percent with Federal funds) would be put into a National oceanographic facilities pool and made available to all competent oceanographers. A Federal agency that is competent to handle all of the administrative aspects of ship operations would be assigned responsibility for this pool. This responsibility would include selection and training of operating crews, provision of shore-based support facilities, and the scheduling of routine overhauls. In addition, this agency would arrange for all aspects of the financing of this pool, including testimony before Congress at budget hearings. In its facility operation aspects the designated agency would perform services that are analogous to those performed by MSTS (Military Sea Transportation Service), which has operated the Navy's oceanographic research vessels with rather outstanding success. In those aspects of its activities which cover financial responsibility for the facilities, it would subsume many of the facility support tasks that are currently the responsibility of ONR and NSF.

2. Advantages

The existence of a centralized pool of ships and other facilities would go a long way towards the establishment of a national laboratory or facility system. The operation of the pool would be such that the ships scheduling and configuration would be determined by representatives of the user institutions subject to the constraints imposed by ship safety and budgetary limitations. Typically, a group composed of representatives of the ten or 20 largest oceanographic institutions might be members of the scheduling and operations control group. To insure that incestuous relationships and logrollings did not obtain, knowledgeable public members who are not associated with the user institutions might be asked to serve on the scheduling and facilities control groups. Typically, the public members would be drawn from industry and parts of the federal government which did not have responsibility for maintaining the funds of ships within the pool.

A single budget line should be developed to provide funds for the maintenance and operation of the vessels within the research fleet. A civilian agency would be given responsibility to stand before Congress and justify the utilization of the vessels and develop documentation to justify the magnitude and necessity of this budget item. The

advantage of this system to the Nation would mean that in times of budget stringency the size of the oceanographic fleet could be viewed as a whole. If it were necessary to reduce the magnitude of the fleet, then a 10-percent cut would result in a lay-up of 10 percent of the available vessels in the ocean. Under the present system, where each institution must develop its own funds for each ship, a certain critical level of budget deficiency forces an entire ship to be laid up. Thus, a 25-percent cut in the operating funds of a vessel under control of one institution may in effect be a 100-percent cut. The existence of centralized research vessel management would insure that the size of the National fleet would expand or contract in a manner appropriate to the size of the National oceanographic program.

The proposed system would result in the elimination of multiple support staffs. It would insure professional care and the adoption of standard procedures for all of the vessels. It is expected that the operating agency would handle such services as recruitment and training of crews, port clearances, maintenance, operation of ships, and upgrading of physical facilities on board ships. In the event that marked advances were made in the technology applicable to oceanographic vessels, then the application of these advances to individual ships could be programmed on a comprehensive basis. Under this option each institution would not have to individually raise funds for complex and costly electronic equipment and individually train maintenance and operational personnel. In addition, ships could then be replaced on an orderly basis related to their age and usefulness rather than on the basis of the priorities of one oceanographic institution versus another.

The group which actually maintained and operated these ships might be a contractor to the responsible Federal agency. Indeed, one of the present oceanographic institutions might serve that role. On the other hand, private industry or nonprofit groups could also serve the necessary function.

The tradition that institutions maintain intimate control of the operation of their own vessels is reasonably deeply ingrained in the system. Nonetheless, despite the strong views of many oceanographers, there is considerable evidence that ship operation is not a necessary function of an institution that is undertaking oceanographic research. The Navy laboratories and at least one Federal contract research center have had outstandingly successful experience in developing operations at sea, using MSTTS-operated vessels over which they did not have institutional control. Their experience has shown that the at-sea operations of such vessels proceeds quite smoothly and that there is no significant loss in operational flexibility in this mode of operation.

One would hope that in the course of time a national service would develop in which officers made a career of serving aboard oceanographic research vessels. Promotion and advancement toward senior command might require collateral fitness reports from senior scientists who cruised on their vessels. Such comment would evaluate the cooperative spirit and oceanographic competence of the captains and crews of the oceanographic vessels in the pool.

The other key facilities of a large oceanographic laboratory which are basically overhead in nature are usually involved in engineering and equipment maintenance. There is an immense convenience in having such staffs available at an oceanographic institution. Possibly the services of the personnel should be under a comprehensive agency, which would either provide engineering services by regional grouping or provide them on a continuing basis to individual institutions.

Major institutional items of hardware and software such as computers and program libraries should not and do not have to be unique to an individual oceanographic institution. Within the last few years, computer technology has changed extraordinarily rapidly. It is now possible to make extensive use of time-shared computers from many dispersed

geographic locations. Thus while it is at present somewhat awkward to share a computer one can certainly envisage that in the future no University/National laboratory will have its own dedicated digital computer. For research the only requirement is immediate and convenient access to a computer. One may have reasonable confidence that computer technology is moving forward rapidly enough so that a central computer might be located in some city which had a convenient labor supply for application programmers and computer operators. This would tend to increase the efficiency, to lower overhead costs, and to relieve oceanographic institutions of the need of recruiting computer operators and programmers. Furthermore, every institution would have a much larger computer available than it presently has.

3. Disadvantages

The overall objectives of the U.S. Government should be the support of oceanographic research and the development of an enhanced national maritime capability. From this standpoint the Panel believes that this option has a number of disadvantages. It does not address the problem of increasing institutional size to allow them to develop a greater training and/or research capability. While some such increase may be implicit through enhanced efficiency of operation, this proposal does not create a center which could act as a home for groups which can undertake a larger scale of experimental work than is now possible with the current institutional configuration.

This option would probably encounter some objections from the oceanographic institutions. While the validity of such objections might reasonably be questioned, the fact remains that there has been a tradition of institutional control of facilities. Proponents of this tradition can point to the general success and convenience of such operations. The existence of a new agency or a pool, however well run, would result in greater inflexibility in scheduling. Ship operating schedules are often worked out 2 years ahead. An increase in scheduling delays might create impossible situations. A greater degree of travel and coordination would be required, which would represent something of an inconvenience to the ship operators.

Centralized operation of facilities would undoubtedly tend to enforce uniform standards of equipment. While there may be an effective economy in such standardization, it would reduce the desire for and possibility of innovative changes on the part of the working personnel of the institutions. They would be led to feel that such changes were not among their prerogatives. Admittedly, the oceanographic community must eventually realize that if it is to do big science, then the individual scientist can no longer modify major facilities in an arbitrary way. Nonetheless, the tradition of making such modifications is well ingrained in the system and has resulted in some striking advances.

The adoption of this option would also serve to centralize the determination of fleet and facility sizes within the same organization that operates this fleet. From the standpoint of National interest it is not clear that this would be the most useful configuration. If a NOAA were to be developed, then the operation of National oceanographic facilities would be an ideal function for this agency. However, unless a NOAA-like institution were to be developed, considerable objections could be raised to assigning agency responsibility to anyone of the presently existing sponsors of oceanographic research.

C. Option 3

1. Concept

Under concept 3 it is proposed that a number of regional laboratory consortia be established, each consisting of a geographical cluster of existing laboratories, with one strong member of each group being designated as the Regional Lead Laboratory. This

approach would tend to result in strong interaction between diverse research laboratories without introducing the strains associated with a radical restructuring.

The above concept can be implemented by arbitrarily subdividing the oceanographic research of the United States into four or more main groupings: Northeast United States, with the Woods Hole Oceanographic Institution designated as lead laboratory; Southeast United States, with the University of Miami as lead laboratory; Northwest United States (including Alaska), with the University of Washington as lead laboratory; and Southwest United States (including Hawaii), with the Scripps Institute of Oceanography as lead laboratory. The research units of the individual laboratories would be locally controlled and administered, but cooperative research programs would be encouraged. The lead laboratories would be authorized to procure, develop, and maintain reasonably large regional fleets with diverse and exotic capabilities which would be available to all the members of each laboratory grouping. Unique or expensive facilities such as data reduction centers, deep submergence vehicles, and large arrays of buoys would be located at, or be under the administration of, the local lead laboratory; however, these facilities would be available to all. Multiple source funding of mission oriented research would be continued, but additional funds would become available (via an organization like NOAA) for the development of the local laboratory and the lead laboratory facilities. All member laboratories will have equal standing, regardless of affiliation (government, university, or private institution). User committees composed of scientists from the individual laboratories would be established for the equitable and efficient use of the regional fleets and the unique facilities.

2. Advantages

The advantages of such an operational plan are clear. The individual research programs of the laboratories making up each regional consortium would be initiated, nurtured, and developed locally, with inputs from other member laboratories only when appropriate and mutually agreeable. Hence individuality of scientific program, responsive to local conditions and pressures and molded according to the discretion of the local research scientists, would be preserved. University laboratories would be encouraged to maintain and develop their own expertise and scientific strengths as well as to couple with the nonuniversity members of the consortium. Fellowship programs could be initiated to attract qualified graduates of the various conventional scientific disciplines into postgraduate research programs in oceanography which could also be carried out at non-university member laboratories. Thus the dual character of a graduate training institute and a research facility could be incorporated into all member laboratories. And the key scientists of the nonuniversity laboratories would have the opportunity to enter into the role of adjunct professors.

The concept of having available unique or unusually expensive facilities at the regional lead laboratories would be incorporated in this plan of action. It would now be possible to justify large capital investments for facilities which would be shared by several user research teams. Efficient use of these shared facilities would be assured by the demand and competition resulting from their availability to all member laboratories. Also, well-qualified supporting staffs, such as those required for fleet maintenance and development, could be attracted and held by the opportunities and challenges inherent in a large and diversified regional fleet.

It should be noted that there are attendant advantages to any plan of action which has shared facilities as a central element. Setting up user committees for efficient utilization of such facilities automatically provides a simplified and informal method of program coordination. The principal scientists making up the utilization committee must compare and evaluate the programs of one another to determine scheduling priorities. This type of spontaneous interaction will frequently generate cooperative programs. At the very least, familiarity with the research programs of other groups will minimize duplication of effort.

Finally, this type of program emphasizes the development of the research capabilities of each of the member laboratories in a manner and rate which is locally determined. The character of the individual member laboratories will not be modified by external committees. There should therefore be no consequent legal problems or charter changes necessary for the implementation of this program.

3. Disadvantages

There are, of course, attendant disadvantages to this proposal. An obvious flaw is that associated with the rather arbitrary division of the U.S. oceanographic effort on a geographical basis. This would tend to lump together member laboratories having very little in common. The regional fleets associated with each laboratory consortium would not necessarily satisfy the requirements of all members of the consortium. Yet a grouping based on some criterion other than that of location becomes extremely involved. Selecting the grouping on the basis of common interest, for instance, in addition to mixing together laboratories geographically removed from each other, would also result in minimizing the crossfertilization of ideas which might result from a heterogeneous grouping. Also, most research laboratories have diversified interests. It is unlikely that any laboratory group could be assembled in which all interests would be common.

The concept of a regional fleet associated with a geographically contiguous regional laboratory consortium has similar inherent difficulties. Being located, say, in the northeast United States does not automatically result in a laboratory developing interests in the North Atlantic exclusively. By what mechanism, then, would a member of the southwest consortium gain access to the North Atlantic regional fleet? Would the user committee for the northeast regional fleet give preferential treatment to fellow members from the northeast U.S. laboratory consortium? On the other hand, establishing user committees composed of key scientists from the entire U.S. would be unwieldy and would most likely be impossible to convene because of conflicting commitments. Establishing a user committee in Washington, on the other hand, negates many of the advantages associated with local control and interaction.

The selection of a Regional Lead Laboratory also presents a rather difficult problem. In certain geographical areas the choice may be rather straightforward. However some regions of the United States contain several strong oceanographic laboratories. Making a selection between such laboratories will be, to say the least, an extremely difficult and touchy problem.

D. Option 4

1. Concept

Under option 4 the U.S. Government would accept the present institutional form of the oceanographic laboratories without attempting to sponsor changes. It would attempt to encourage the growth of oceanographic research and training by increasing the magnitude of funding and by introducing more flexibility into the funding pattern. The U.S. Government would block-fund facilities, their support, and their overhead costs at existing and/or evolving oceanographic laboratories and institutions. As a possible variant of this option, the Government might centralize all of the funding for oceanographic research and educational institutions in the hands of one agency. This agency could coordinate the funds and services needed by other Federal agencies. If NOAA were created, it could undertake responsibility for the funding and support of the civilian aspects of the national oceanographic research effort.

II. MANPOWER CHARACTERISTICS BY AREAS OF ACTIVITY

A. Marine-Related Employment in the Private Industry Sector

1. Shipbuilding and Advanced Technology

Of the 1428 engineering job holders in one large shipyard, 499 have two-year Associate-of-Arts degrees, 70 have science degrees, and 68 have degrees in other fields such as social science, history, or education. Of the scientists employed, 80 percent were trained in chemistry. No oceanographers or ocean engineers were indicated. Sixty-six percent of the engineers were trained in mechanical, electrical, civil, or industrial engineering.

The advanced technology industry (research submersibles, ocean platforms) is likewise heavily populated with engineers. One firm employs two oceanographers out of a total of 26 scientists and two ocean engineers out of a total of 111 engineers. For the remainder, the principal science training has been in either physics, mathematics, chemistry, or metallurgy. In the area of advanced technology, engineers were found to be predominantly mechanical, electronic, electrical, and civil. Eighty of the engineers out of a total of 459 identified in this area did not have four-year college degrees.

2. Offshore Oil

The personnel reported in offshore oil activities are those engaged in exploration and production activities. The data exclude personnel involved in that component of the oil industry's research and development activities related to petrochemicals. The numbers, however, do include contract services personnel engaged in exploration and drilling.

The scientists employed by the oil industry are predominantly geologists. Some physicists, geophysicists, and mathematicians are also employed. Although the National Petroleum Council study does not list oceanographers and ocean engineers, small numbers are known to be employed by the multipurpose geophysical surveying contractors and consultants. The engineers of the oil industry are predominantly petroleum engineers. The industry also employs relatively large numbers of mechanical, civil, and electrical engineers, and smaller numbers in other discipline areas.

3. Merchant Marine

Merchant Marine employment figures do not give any indication of personnel with educational backgrounds in oceanography or ocean engineering. However, it is known from the survey of university curricula in marine sciences that some of the maritime academies now offer such courses. In addition, part of the cadet-midshipman's "sea year" at the U.S. Merchant Marine Academy can now be spent aboard government and private ocean-research vessels.

4. Coastal Dredging

The engineers in this category were reported to be civil, mechanical, and electrical. Technicians include surveyors as well as engineering aides.

5. Aquaria and Parks

The scientists include biologists (general), zoologists, and chemists. No oceanographic training was indicated.

B. Marine-Related Employment in the Academic Community

The academic community is one of the major employers of marine scientists and ocean engineers. Data which were obtained from a review of university curricula in marine sciences were supplemented by a NASCO oceanographic laboratory survey of April, 1969. The academic community employs 1534 people associated with oceanography or ocean engineering in teaching capacities and 1758 people in research capacities. Many of these have dual functions for both teaching and research. Of those people in instructional positions, 438 were identified as having formal training in one of the oceanographic disciplines. Presumably the remaining 1100 people in this category received their formal training in fields other than oceanography.

A breakdown of the formal academic training of the noninstructional staffs of academic institutions was not available. Informal estimates by those who have been closely associated with this group indicate that a relatively small percentage of these people (10 to 40 percent) have had their formal training in one of the oceanographic disciplines.

C. Marine-Related Employment in Government Agencies

One shortcoming of the Federal statistics is that ocean engineering is not one of the standard job classifications. Another pitfall in the use of the statistics is that many of the administrators in oceanographic activities have scientific or engineering job titles. Table 2 lists the results of the 1969 survey in government employment. A number of technicians who were identified by job titles are listed under scientific or engineering technician categories. This placement may be in error, but the total number is as reported.

1. Navy

The total number of scientists, engineers, and technicians employed by the Navy is somewhat larger than is shown by Table 2. The scientists, engineers, and technicians employed by NASC, NFEC, NESC Admin., Intel., BuMed, NCC, NRTC, Security, and Marine Corps are not included in this table.

The biological scientists include—in addition to the general biologists—microbiology, physiology, entomology, soil conservation, and forestry. No oceanographic disciplines are indicated.

Over 50 percent of the physical scientist population of the U.S. Navy is considered to be physicists, and 17 percent chemists. Personnel with job titles of oceanographer (574), cartographer (282), geophysicist (99), meteorologist (67), geodist (41), and geologist (11) are more likely to have had some training in oceanographic institutions. Other physical science disciplines in marine-related activities include metallurgy, astronomy, health physics, photographic technology, textile technology, forest products technology, and hydrology.

The engineering in the civilian establishment of the Navy is largely electronics, mechanical, general, electrical, aerospace, and civil engineering. Ocean engineers is not a Navy job category.

2. ESSA

ESSA conducts in-house programs of scientific research, mapping, and charting. The figures in Table 2 include only the staffs of the ESSA research laboratories. Cartographers are largely not reported here. Of the 464 physical scientists in ESSA laboratories, over 73 percent are classed as meteorologists and physicists. Eight other

Table 1
PRELIMINARY SURVEY DATA
University and Industrial Scientific, Engineering, and Technical (S-E-T) Positions in Marine Activities

| Non-Federal Activity | Biological | | Physical | | Engineering | | Naval Arch | | Total S-E-T |
|--|--|---------|------------|---------|-------------|-----------|---|--|----------------------------|
| | Sci | Technic | Sci | Technic | Engrs | Technic | Marine Engrs & Others | | |
| (Oceanographic disciplines in parentheses) | | | | | | | | | |
| Shipbuilding | | | | | | | | | |
| 1 large yard ¹ | 0 | 0 | 25 | — | 1428 | 675 (est) | 97 Nav. Arch. (N.A.) | | 2225 |
| 23 design firms & 3 yards ² | 0 | 0 | 3 | — | 1190 | 2040 | 170 N.A. | | 3403 |
| Adv. Technol. ³ | | | | | | | | | |
| 4 large firms ³ | 7 | 0 | 73 (2) | — | 459 (2) | 132+ | incl N.A. | | 671 |
| Subtotals | 7 | 0 | 101 (2) | | 3077 (2) | 2847 | 267 N.A. | | 6299 |
| Offshore Oil ⁴ | — | — | 1221 | 206 | 1868 | 750 | | | |
| Merchant Marine ⁵ | — | — | — | — | — | | 10000 Mar. Engrs (M.E.) (plus 8600 Deck O's and 1600 Radio O's) | | 10000 |
| Coastal Dredge Contractors ⁶ | — | — | — | — | 400 | 150 | | | 550 |
| Aquaria & Parks ⁷ | 133 | ? | 7 | ? | 10 | ? | | | 150 |
| Academic Teaching ⁸ | 477 (108) | — | 560 (281) | | 263 (49) | — | 30 N.A. | | 1534 teach. (1758 rsch) |
| Research ⁹ | (850 professionals plus 908 technicians and lab staff) | | | | | | | | |
| TOTALS | 617 (108) | ? | 1889 (283) | 206 | 5618 (51) | 3747 | 297 N.A. 10000 M.E. (plus 8600 D.O. and 1600 R.O.) | | 18533 |

¹Technicians estimated on basis of information supplied by Naval Ship Systems Command.

²Estimates based on information supplied by Naval Ship Systems Command.

³Four of the largest industrial firms engaged in advanced undersea technology.

⁴Based on a report of the National Petroleum Council and consultation with NPC staff. Not included in this listing are 1196 deck officers.

⁵1188 marine engineers, and 271 radio officers on oceanic oil tankers.

⁶Supplied by MARAD; licensed officers in the U.S. Merchant Marine, 1969.

⁷Supplied by Corps of Engineers.

⁸Supplied by National Recreation and Park Association.

⁹Data from "University Curricula in Marine Sciences, 1969-70" (in press); 43 undergrad. and 71 grad. schools.

Data for 1968 from a survey by NASCO, April 1969 (unpublished); 34 academic institutes, 10 of which are large.

disciplines, including oceanography and geophysics, make up the remainder. Some 106 out of 108 engineers are oriented toward electronics, while the other two are mechanical engineers. Electronic, meteorological, and physical science technicians make up more than 96 percent of the technician work force.

Within ESSA's officer corps, an integral part of C&GS, 29 officers have received formal undergraduate and graduate training in ocean science and ocean engineering. In addition, 11 other officers have taken advanced studies in marine science.

All personnel employed by MARAD appear to be involved with administrative duties. Mechanical and general engineers and naval architects comprise 85 percent of the engineering work force. Over 50 percent of the technicians are shipbuilding inspectors, while the remainder are naval architect or engineering technicians. MARAD also operates the U.S. Merchant Marine Academy at King's Point, New York, where at least two members of the academic staff have had formal oceanographic training and several others have ocean engineering backgrounds.

3. Bureau of Commercial Fisheries (BCF)

BCF employs the largest number of fisheries biologists, 445 out of a total 486 biologists. The remaining biological scientists are in seven subdisciplines. Physical scientists employed by BCF include 76 chemists, 39 oceanographers, nine physical scientists, two meteorologists, and one health physicist. Over half the engineers are classified as chemical, while the remainder are classified as mechanical, electronic, and general engineers. Some 75 percent of the technicians are biological technicians. The remaining technicians work as physical science, electronics, or engineering technicians.

4. Bureau of Sport Fisheries and Wildlife (BSF)

BSF reports 30 fisheries biologists, four wildlife biologists, three biological technicians and one physical science technician.

5. Bureau of Mines

The Bureau of Mines, in its marine mineral exploration program, has four physical scientists, two geologists, two geophysicists, seven mining engineers, three mechanical engineers, and five electronics engineers; also three marine engineering, one cartographic, and one physical science technician.

6. Federal Water Pollution Control Administration

FWPCA is concerned with pollution problems of both fresh water and salt water. It is estimated that the majority of its scientific and technical staff works on marine problems about 35 percent of the time. The biological scientists include 63 biologists and 18 microbiologists. Chemists make up 64 percent of the physical scientists. Some 148 out of 155 engineers are employed as sanitary engineers. Over half of the technicians are physical science technicians, while the remainder are biological and engineering technicians.

7. U.S. Geological Survey

Only half of the USGS staff works on marine-oriented activities on a full-time basis. The remainder is on "other than full time." Some 60 percent of the physical scientists employed by USGS are geologists, while 20 percent are hydrologists. Chemists, geophysicists, oceanographers and mathematicians make up the other physical science

Table 2
PRELIMINARY SURVEY DATA
Federal Civilian Scientific Engineering and Technical Personnel in Marine Activities, 1969

| Federal Agency | Biological | | Physical | | Engineering | | Naval Arch | Total S-E-T |
|--|------------|---------|------------|---------|-------------|---------|-------------|----------------|
| | Sci | Technic | Sci | Technic | Engrs | Technic | Marine Engr | |
| (Oceanographic disciplines in parentheses) | | | | | | | | |
| <u>Navy</u> | 66 | 29 | 3820 (574) | 622 | 7741 | 4813 | 324 | 17415 |
| <u>R&D</u> | 4 | 2 | 437 | 205 | 5425 | 5992 | 1478 | 13543 |
| <u>Marine-Related Facilities</u> | | | | | | | | |
| <u>Commerce</u> | | | | | | | | |
| <u>ESSA</u> | — | — | 464 (34) | 127 | 108 | 102 | — | 801 |
| <u>MARAD</u> | — | — | | | 84 | 26 | 36 | 146 |
| <u>Interior</u> | 486 | 150 | 127 (39) | 43 | 18 | 9 | — | 833 |
| <u>BCF</u> | 34 | 3 | — | — | — | — | — | 37 |
| <u>BSF</u> | — | — | 11 | 5 | 9 | 3 | — | 28 |
| <u>BuMines</u> | 3 | — | | — | | — | — | 3 |
| <u>NPS</u> | 81 | 12 | 95 (8) | 41 | 155 | 19 | — | 403 |
| <u>FWPCA</u> | 3 | — | 116 (5) | 32 | 40 | 26 | — | 217 |
| <u>USGS</u> | 3 (3) | — | 1 | — | — | — | — | 2 |
| <u>OWRR</u> | 1 | — | | | | | | |
| <u>Other</u> | | | | | | | | |
| <u>Army C of E</u> | 20 (20) | — | 128 | 24 | 858 | 676 | 40 | 1746 |
| <u>DOT-USCG</u> | — | — | 16 (12) | 5 | 263 | 25 | — | 309 |
| <u>HEW-PHS</u> | 23 (1) | 14 | 7 | 2 | 1 | — | — | 47 |
| <u>Smithsonian</u> | 52 (2) | 24 | 13 (4) | — | — | — | — | 89 |
| <u>AEC-NASA-NSF</u> | 9 (1) | — | 22 (3) | — | 8 | 3 | 3 | 45 |
| <u>Totals</u> | 782 (27) | 234 | 5257 (679) | 1106 | 14710 | 11694 | 1881 | 35664 |

disciplines. There is only one full-time oceanographer. The engineers are of two disciplines, hydraulic and petroleum. Physical science and engineering aides comprise over 86 percent of the technicians. The others are electronic or cartographic technicians.

8. The Corps of Engineers

The Corps of Engineers employs 20 marine biologists in that part of its civil works program which is marine oriented. The physical science disciplines include hydrology, chemistry, geology, meteorology, geodesy, mathematics, and a general and miscellaneous category. Over 78 percent of the engineering employees are civil engineers, while the remainder are mechanical, electrical, electronic, general, and sanitary engineers. The Corps also lists 35 naval architects and five marine engineers. Half of the technicians are in engineering categories, while the others include construction inspectors, surveyors, draftsmen, and electronic technicians.

9. U.S. Coast Guard

The civilian staff numbers reported for the Coast Guard include faculty members (seven scientists, eight engineers) at the Coast Guard Academy. Some 12 out of 16 physical scientists are oceanographers; two physicists and two mathematicians make up the remainder. The USCG employs 84 civil engineers, 34 electronic engineers, and 49 general engineers, with the remainder split among four other engineering categories. Some 13 naval architects are listed. Technicians are mostly naval architect, mechanical, and electrical technicians, plus five physical science aides.

10. Health, Education, and Welfare—Public Health Service

The listed HEW-PHS staff engaged in shellfish laboratory activities includes commissioned officers. General biologists and microbiologists dominate the biological scientists. The physical scientists are chemists. Technicians are discipline-oriented in their respective categories.

11. The Smithsonian Institution

The Smithsonian staff includes 50 zoologists, two marine botanists, nine paleontologists, and four marine geologists. The technicians were not categorized, but it is believed they are mostly sorting center (biological) aides.

12. Other Agencies

The Atomic Energy Commission, the National Space and Aeronautics Administration, and the National Science Foundation staffs listed are believed to be all engaged in administrative work. Of the biological scientists, NSF has seven biologists, and AEC one marine biologist and one botanist. In addition to the three oceanographers shown, the physical scientists include chemists, physicists, mathematicians, and geologists. Engineers are either civil, general, or marine engineers.

13. Military Oceanography

Some 121 naval officers are reported to have a postgraduate education in oceanography. Some 450 members of the Naval Weather Service Command have had oceanographic training, and 900 enlisted personnel have had air/sea interaction or special prediction training. The Coast Guard reports 20 officers with academic backgrounds in oceanography and 227 others with various scientific discipline backgrounds. The Coast Guard also reports some 2657 officers with engineering backgrounds (1635 from the Academy) with 20 discipline areas reported.

III. PROJECTIONS OF FUTURE MANPOWER SUPPLY AND DEMAND IN OCEAN-RELATED ACTIVITIES

A. General Comments

Estimating future manpower requirements is, at best, a risky, highly speculative undertaking. There are many pitfalls in a field that has many permutations and combinations among scientific, engineering, and technician disciplines. These difficulties are further compounded by the vagaries of human nature and behavior. The greatest pitfall would be to make simple extrapolations, of past or present experience, into the future. At best, only qualitative estimates of trends can be obtained.

The level of ocean-related activities is almost completely dominated by the level of Government spending. Except for the offshore oil industries and parts of the fishing and shipbuilding industries, employment is a strong function of Governmental support of research and development, of Government subsidies, or of revenue sharing. To project future manpower requirements, one must project Government spending in the various oceanic activities. In this regard, marine activities must compete with all other Government activities for public revenues. At present marine research and development obtains about three percent of all Federal research and development expenditures. Shipbuilding and fishing subsidies add to the marine-related Government expenditures.

B. Assumptions

There are a number of reasons for expecting an increased demand for scientific, engineering, and technician manpower in marine activities. The demands on the marine environment should grow at least as fast as the national rate of population growth, which is currently growing at a rate of approximately three percent per year. With an expanding population in the United States and elsewhere, it may be safely assumed there also will be an expanding economy. It could be argued that research and development work in the marine environment calls for and will receive a larger amount of tax dollar support than it now receives because of the unexploited potential of the ocean. However, our society may elect to fund other national priorities in preference to an enlarged effort in oceanography. It is sufficient for the present purpose to assert that growth of Government-supported marine activities will be steady, and it will be more or less in concert with the population increase. Admittedly, the rate of overall increase may climb abruptly if revenues from the oceans climb. The effects of the offshore oil industry on the manpower spectrum is a good example of an abrupt change in demand.

Another reason to anticipate a slow change in the manpower picture is the inertial effect of the large number of people already employed in oceanographic activities by the Navy. It is not expected that this manpower pool will fluctuate very much in size or shape over the near-term future.

Projections of future manpower requirements are considered in two phases: (1) an attrition rate for the people already employed in the field, and (2) an estimate of growth or expansion of activity. The Panel believes that it is realistic to assume an attrition rate of five to six percent. This is based on an assumed annual replacement of the work force of three percent due to retirements and two or three percent for lateral transfers to other fields, or other reasons.

C. Projections of Ocean-Related Manpower by Activity Area

By inspection of Tables 1 and 2, one can readily deduce that the Government and academic institutions are the principal employers of oceanographic scientists. Industrial

employment is primarily in engineering occupations. The mix of scientific, engineering, and technician disciplines varies with each area of activity, making projections more difficult.

The principal ocean-related activities by industries were examined in terms of the disciplines learned at marine or related science schools, and by employment levels depicted in the previous tables. Attrition rates and assumed growth rates, which vary with the area of activity, are applied to obtain rough estimates of personnel needs. (See Table 3.)

The reasons why so few of the engineers employed in ocean-related activities are called ocean engineers is not too clear. Ocean engineering as a discipline area is only several years old. Perhaps it is misleading to term it a discipline area because ocean engineers have subdiscipline specialties related to mechanical, electrical, and civil engineering, just as their land counterparts do.

As a result of the foregoing considerations, it is not realistic to project future needs for ocean engineers on the basis of present employment levels. There simply are not enough ocean engineers to constitute a base level, nor enough experience to know their versatility or worth in all areas of activity.

Shipbuilding manpower statistics do not indicate any presently employed marine scientists or ocean engineers. There are approximately 2500 engineer positions in the shipbuilding industry. About 500 of these are held by persons without four-year college degrees. The anticipated demand for engineers, including ocean engineers, is indicated. A large number of technicians are already employed (>2700). Our increasingly complex technology would indicate an increased demand for technician manpower. The demand for naval architects and marine engineers is thought to be small, but constant.

Advanced technology, like ocean engineering, is a new field. There is little experience on which to draw. If one considers manpower for instrument design and manufacture (not included in Tables 1 or 2), more scientists than shown are employed. However, the total numbers are small. Turnover is estimated at five to ten persons per year. Growth would be primarily in the engineering aspects.

Scientists and engineers engaged in offshore oil exploration and production were not reported by the National Petroleum Council in its manpower study. The numbers listed in Table 3 are estimates of those marine specialists thought to be engaged by exploration contractors and ocean engineering consulting firms. Offshore oil could experience a sharp increase in demand for oceanographic and ocean engineering manpower, but it is estimated that the need would not exceed 100 per year.

The Merchant Marine, whose licensed officers are supplied largely by the one Federal and four State maritime academies, is felt to have a relatively steady manpower situation. When one includes the annuitants from the military fleet and recruits from the fishing fleet and from the ranks, it appears that supply is now and will continue to be about equal to demand. A new source of licensed Merchant Marine officers has developed in the past two years. Officers are now produced by union-operated licensing schools for Merchant Marine personnel.

The manpower of the academic institutions and the Government should be considered collectively, and in the same light. About eighty-five percent of academic oceanographic research is federally supported. As mentioned earlier, Federal and academic activities undertake most of the scientific activities in oceanography. Accordingly, they employ most of the scientific graduates in the field. Overall, it is felt that the growth of scientific activities in oceanography will be relatively nominal and that the growth of engineering activities will be limited by the availability of manpower and funds.

Table 3
Projections of Ocean-Related Manpower Needs by Activity Area, 1970-1980

| Activity | Ocean-Related Disciplines | Employment 1969 | Estimated Manpower Needs/Yr Due to | | | Summed Needs/Yr |
|-------------------------------------|---------------------------|-----------------|------------------------------------|--------------------|---------------|-----------------|
| | | | Turn-over (@ 5%) | Expansion (var. %) | Expansion No. | |
| Shipbuilding | Oc. Engrs. | — | — | slight | 10 | 10 |
| | Nav. Arch. | 270 | 14 | 2 | 5 | 19 |
| | Technic (var.) | 2700 | 135 | 5 | 135 | 270 |
| Adv. Tech. | Biol. Sci. | 7 | — | 10 | — | — |
| | Phys. Sci. | 73 | 4 | 10 | 7 | 11 |
| | Oc. Engr. | 459 | 23 | 10 | 46 | 69 |
| Offshore Oil | Phys. Sci. | 60 est | | | 6 | 6 |
| | Oc. Engr. | 90 est | | 10 | 9 | 9 |
| | Technic | 75 est | | | 8 | 8 |
| Merchant Marine | Lic. Ships Off. | 20200 | 1010 | stable? | | |
| Academic Inst. Teach Research | Biol. Sci. | 477 | 24 | 3 | 14 | 38 |
| | Phys. Sci. | 560 | 28 | 3 | 16 | 44 |
| | Oc. Engr. | 263 | 13 | 10 | 26 | 39 |
| | Technic | 908 | 45 | 10 | 90 | 135 |
| Summary Fed. Agencies | Fish Biol. | 475 | 23 | 2 | 10 | 33 |
| | Biol. Sci. | 307 | 15 | 10 | 30 | 45 |
| | Phys. Sci. | 4578 | 230 | 3 | 135 | 365 |
| | Oceanographers | 679 | 34 | 3 | 20 | 54 |
| | Engr. | 14710 | 735 | | ? | > 735 |
| | Technic (var.) | 13034 | 650 | 10 | 1300 | 1950 |
| | Nav. Arch. | 1881 | 95 | 2 | 38 | 133 |

D. Student and Graduate Level Populations in Marine-Related Academic Institutions

Table 4 lists both student enrollments and degrees granted in 1961 and in 1968 for eight marine and related curricula programs. While the Table indicates a significant growth in the numbers of schools, enrollments, and graduates over the past nine years, one should interpret this growth curve cautiously. The data are based on questionnaire surveys. The same schools were not all represented throughout the period. Some schools have redesignated their programs as being marine related without changing the intrinsic content in an appreciable manner. This phenomenon is especially true in basic science and basic engineering. Finally, the base from which the growth began was relatively small. Consequently, any increase would seem relatively large. Nevertheless, the increase in oceanographic, ocean engineering, and marine technician programs is real.

The student population represented by the enrollment numbers is not completely defined. The baccalaureate candidates are reported to be third- and fourth-year students, but it is not known how many are part-time students. Many of the advanced degree candidates are known to be part-time students. Also, it is not known how large a fraction of the graduates go on to higher degrees or postdoctoral education. The survey from which the student data of Table 4 were collected did not determine the disciplinary distribution of students in the sciences. These data were obtained from a survey of twelve large oceanographic institutions conducted by the Office of Naval Research in September, 1968. The results are shown in Table 5. These data indicate that about one-third of the graduate students are in biological sciences, one-third in geology and geophysics, and one-third in physical and chemical oceanography. The subdisciplinary categories of the ocean engineering group is unknown.

One should also keep in mind the time it takes to earn advanced graduate degrees. NAS Publication 1489, "Doctorate Recipients from U.S. Universities," indicates a median total time of 7.6 years from baccalaureate to doctorate for earth science students, and 2.1 years for a master's degree. Similar times are indicated for ecology and engineering students.

IV. CONCLUSIONS

Because of the many intangibles involved, it is not possible to develop a precise equation for the supply and demand of oceanographic manpower. In the past, less than one person in ten employed in an oceanographic research activity had formal training in an oceanographic discipline. Clearly, both the supply and demand for manpower with oceanographic training will be a sensitive function of the total Federal funds invested in the field.

Table 6 presents an approximate correlation between future employment levels and student populations in marine-related schools. By inspection, it would appear that the enrollments and the anticipated number of graduates will be sufficient to meet personnel needs in the foreseeable future. This conclusion is especially obvious in the biological sciences. It is anticipated that over 800 graduates per year will be available to satisfy what appears to be an average annual need for 116 biological scientists.

At present, a majority of personnel in the physical science group were not trained as oceanographers. Their formal education was in fields such as physics, chemistry, meteorology, and geology. It is anticipated that components of the national reservoir of people with training in these fields will be available to meet future personnel needs. It should be borne in mind that the marine scientist population is most closely related to the Government's programs, and estimated projected needs were quite nominal.

Table 4
Oceanic Academia
(All Reporting Institutions)

| Curricula and Degrees Offered | 1960-61 | | | 1968-69 | | | 1960-69 |
|-------------------------------|-------------|------------|-----------------|-------------|------------|-----------------|-----------------|
| | No. Schools | Enrollment | Degrees Granted | No. Schools | Enrollment | Degrees Granted | Degrees Granted |
| Oceanography | | | | | | | |
| BS | 5 | 83 | 13 | 16 | 1451 | 300 | 925 |
| MS | 16 | 202 | 40 | 31 | 1005 | 267 | 986 |
| PhD | 16 | 169 | 29 | 28 | 663 | 132 | 511 |
| Marine Relat. Basic Sci. | | | | | | | |
| BS | 4 | 34 | 10 | 26 | 1201 | 388 | 1076 |
| MS | 14 | 61 | 34 | 36 | 327 | 145 | 582 |
| PhD | 13 | 90 | 27 | 23 | 332 | 73 | 360 |
| Marine Food & Fish. Sci. | | | | | | | |
| BS | 4 | 252 | 32 | 5 | 560 | 142 | 538 |
| MS | 3 | 38 | 16 | 6 | 121 | 50 | 199 |
| PhD | 2 | 35 | 3 | 3 | 89 | 22 | 76 |
| Ocean Engineering | | | | | | | |
| BS | — | — | — | 1 | 179 | 30 | 57 |
| MS | — | — | — | 11 | 313 | 46 | 76 |
| PhD | — | — | — | 3 | 52 | 3 | 7 |
| Marine-Relat. Basic Engr. | | | | | | | |
| BS | 2 | 253 | 123 | 8 | 251 | 105 | 966 |
| MS | 1 | 2 | 2 | 11 | 196 | 45 | 120 |
| PhD | 1 | — | — | 7 | 113 | 18 | 45 |
| Naval Arch. & Marine Engr. | | | | | | | |
| BS | 4 | 559 | 127 | 6 | 766 | 181 | 1396 |
| MS | 2 | 49 | 49 | 3 | 100 | 46 | 398 |
| PhD | 1 | 3 | — | 2 | 21 | 6 | 51 |
| Maritime Academies | | | | | | | |
| BS | 4 | 1639 | 336 | 5 | 1910 | 460 | 3366 |
| Technicians—A.A. | 1 | 3 | 3 | 14 | 942 | 167 | 382 |

Table 5
Graduate Student Specialties at 12 Large Marine Science Institutions, 1967-68*

| Institution | Specialties | | | | | |
|-------------|-------------|-------|-------|-------------------|-----------|------------|
| | Bio. | Chem. | Phys. | Geol. Geophys. | Acoustics | Ocean Eng. |
| U. Alaska | 3 | 6 | 3 | 4 | — | — |
| U. Wash. | 25 | 7 | 30 | 13 | — | — |
| Ore. St. U. | 26 | 10 | 23 | 23 | — | — |
| U. Hawaii | 15 | 4 | 14 | 36 | 2 | 13 |
| SIO | 86 | 18 | 23 | 44 | 5 | — |
| TAMU | 9 | 5 | 18 | 10 | — | — |
| U. Miami | 73 | 1 | 5 | 7 | 4 | 25 |
| JHU | 6 | 3 | 11 | 2 | — | — |
| NYU | — | — | 19 | — | — | — |
| Columbia | 10 | — | 4 | 83 | — | — |
| WHOI | 1 | — | 5 | 3 | 1 | — |
| URI | 42 | 14 | 12 | 13 | — | — |
| Totals | 296 | 68 | 167 | 238 | 12 | 38 |
| Percent | 36.2 | 8.3 | 20.4 | 29.1 | .47 | 4.65 |

*From an ONR Survey, September 1968 (unpublished).

Table 6
Approximate Correlation of Employment Levels and
Students in Marine-Related Schools, 1969

| Specialty | Present Employment ¹ | Projected Needs ⁵ (per year) | Present Enrollment ² | Anticip. Grad/Yr ³ |
|------------------------------|------------------------------------|---|------------------------------------|----------------------------------|
| Physical Sci. | | | BS 1768 | BS 588 |
| Ind. & Acad. | 1889 (283) | 61 | MS 888 | MS 444 |
| Fed. Gov't. | 5272 (682) | 365 | PhD 662 | PhD 94 |
| Biological Sci. ⁴ | | | BS 1444 | BS 480 |
| Ind. & Acad. | 617 (108) | 38 | MS 565 | MS 282 |
| Fed. Gov't. | 778 (27) | 78 | PhD 420 | PhD 60 |
| Engineering | | | BE 430 | BE 143 |
| Ind. & Acad. | 5618 (49) | 127 | ME 509 | ME 254 |
| Fed. Gov't. | 14503 (?) | 725 | DE 165 | DE 23 |
| Marine Engr. (Ind.) | 10000 | ? | ? | ? |
| Naval Arch. | | | BS 766 | BS 255 |
| Ind. & Acad. | 297 | 19 | MS 100 | MS 50 |
| Fed. Gov't. | 1903 | 128 | PhD 21 | PhD 3 |
| Ship Officers (Ind.) | 10200 | ? | ? | ? |
| Technicians (all) | | | | 470 |
| Ind. & Acad. | 4861 (?) | 413 | AA 942 | |
| Fed. Gov't. | 13033 (?) | 1950 | | |

¹Oceanographic disciplines in parentheses.

²All degree levels, 1968-69; phy. sci. are 2/3 of total sci., biol. are 1/3 of sci., plus the fisheries students.

³Estimated from enrollments; approx. 1/3 of BS, 1/2 of MS, and 1/7 of PhD candidates.

⁴Includes fisheries biologists.

⁵From Table 3.

Although it appears that there will be an overall sufficiency of graduate scientists, occasional shortages in particular subdisciplinary specialties might arise. This could be expected to happen if new programs were initiated on a large scale. For example, a large-scale civilian man-in-the-sea development effort would create a need for medical doctors trained in hyperbaric medicine that might easily exceed the available supply.

The situation in relation to the supply of engineers for ocean activities has a different complexion. On inspection, it would appear that there is, or will be, a shortage of engineers. The projection is based mainly on the need for replacements to compensate for normal attrition in the large number of engineers currently employed in the field. No allowance was made for projected growth in Government programs in this manpower area. This large number of engineers is comprised of some 28 subdisciplines (see Table 7) and includes very few "ocean" engineers. The national concern should be not with the apparent shortage of ocean engineers, but with a more general shortage of other kinds of engineers. This is further amplified by the report of the Engineering Manpower Commission of the Engineers Joint Council.* In this report they project a national shortage of some 125,000 engineers by 1971 and over 300,000 by 1976.

It would appear prudent for the ocean-related activities to enhance graduate and undergraduate training opportunities in "ocean engineering," just to assure a certain and viable supply of future engineers.

The situation for technicians closely parallels that for engineers. As ocean technology expands and at the same time becomes more complex, the need for technicians who can maintain, repair, and operate equipment will become more pressing. A shortage of engineers will compound the demand for technical assistance.

As in the engineers situation, it is difficult to make a case for "marine technicians." At least 22 technician disciplines are included in the present survey data. The critical categories would seem to be those which require several years of post-high school education, as opposed to those requiring only on-the-job training. Even so, the technician population can be expanded more quickly and at less expense than the engineering population. The technician can be expected to fluctuate more widely and more rapidly than the professional scientist and engineer manpower pool. It takes less time, on the average, to train technicians, so the work force can be expanded in shorter time. In times of budget stress, technician help is more likely to be released or not hired than the professional categories.

*"Demand for Engineers and Technicians--1966."

Table 7
Position Titles Related to Discipline Backgrounds of Personnel
Engaged in Marine Activities

| <u>Biological Scientists (15)</u> | | |
|-----------------------------------|-----------------------------|--------------------------|
| Aquatic Ecologist | Genetics | Soil Conservationist |
| Entomologist | Husbandman | Wildlife Biologist |
| Fishery Biologist | Marine Biologist | Zoologist |
| Forester | Microbiologist | Biochemist |
| Gen. Biol. Scientist | Physiologist | Botanist |
| <u>Physical Scientists (20)</u> | | |
| Gen. Phy. Sci. | Metallurgist | Geodosist |
| Marine (& Naval) Sci. | Astronomer & Space | Mathematician |
| Physicist | Meteorologist | (& Statistician) |
| Health Physicist | Geologist | Forest Prod. Technol. |
| Geophysicist | Marine Geologist | Textile Technol. |
| Hydrologist | Oceanographer | Photographic Technol. |
| Chemist | Cartographer | Paleontologist |
| <u>Engineers (28)</u> | | |
| General | Aerospace | Industrial |
| Safety | Marine (& Naval) | Hydraulic |
| Fire Prevention | Electronics | Petroleum |
| Materials | Naval Architect | Mining |
| Landscape Architect | Agricultural | Structural |
| Civil | Ceramic | Systems |
| Sanitary | Chemical | Thermal |
| Mechanical | Machine Design | Metallurgical |
| Nuclear | Welding | Textile |
| Electrical | | |
| <u>Technicians (22)</u> | | |
| Biological Technic. | Shipbuilding Insp. | Math Technic. |
| Forestry Technic. | Ship Surveyor | Mechanical Eng. Technic. |
| Engineering Aide | Ind. Eng. Technic. | Phy. Sci. Aide |
| Engineering Technic. | Phy. Sci. Technic. | Marine Eng. Technic. |
| Construction Inspector | Meteorological Technic. | Naval Architectural |
| Surveying | Navigational Info. Technic. | Technic. |
| Draftsman | Cartographic Technic. | Electrical Technic. |
| Electronic Technic. | Geodetic Technic. | |

CHAPTER 4

DISCUSSION OF FEDERAL MARINE LABORATORIES

I. BACKGROUND

A. General Considerations

Today the U.S. Government maintains a large number of Federal marine laboratories which, although generally situated within the continental United States, have missions and responsibilities throughout the world ocean.

By organization, these Federal marine laboratories report to 29 bureaus of 11 departments and agencies of the Federal government. By mission, they support the authorities and responsibilities of their superior agencies which collectively are charged with the responsibility for deriving the maximum benefit to the United States economy, security, health, and welfare from marine science activities. In management, most share such common ills of Federal agencies as excessive layers of superior organizations and lack of control in balancing the resources of men, money, and materials against assigned workload. Quantitatively, there are some 85 Federal marine laboratories. Qualitatively, the Commission's report noted that "some of them are understaffed and underutilized, some involved in research somewhat removed from their agency's primary interests, but most with programs of high quality. These laboratories form a valuable component of the national capability in marine science."

The above comparisons notwithstanding, the Panel cautions against two pitfalls in analyzing the Commission's comments and recommendations bearing on Federal laboratories. First, the term "Federal laboratory," as used in the report is misleading in that there is no typical Federal marine laboratory among the some 85 laboratories of the 29 bureaus of the 11 departments and agencies mentioned above. Second, it must be noted that the Commission apparently focused its investigations principally on the non-Federal marine science communities, then on the nondefense Federal laboratories, and, in particular, only made passing reference to the large marine science centers and laboratories in the Department of Defense.

Thus, the term "Federal laboratory," as used in the Commission's report, actually encompasses a heterogeneous grouping of over 80 mission-oriented laboratories, large and small, which vary in size from some 10 scientists and support personnel at the Bureau of Sport Fisheries and Wildlife Tiburon Marine Laboratory, Tiburon, California to over 3500 professional and support personnel who make up the Naval Ship Research and Development Center, Carderock, Maryland.

It is significant to note that of these many Federal marine laboratories, only the Department of Defense laboratories have a population of over 100 professionals. For example, the largest Bureau of Commercial Fisheries' laboratory (Seattle, Washington) has a total of approximately 83 professional and 61 support personnel. Similarly, the largest Environmental Sciences Administration laboratory (Miami, Florida) has a total

population of approximately 50 personnel. The largest Department of Health, Education Welfare, Bureau of Water Hygiene laboratory (Narragansett, Rhode Island) has about 14 professional and 20 support personnel.

B. Commission's Recommendations

The report of the Commission on Marine Science, Engineering, and Resources contained a number of recommendations which apply to Federal marine laboratories, both directly and indirectly. Quoted below are those recommendations which the Panel considered most pertinent during the course of its review:

- "A small group of institutions, which should include but not be restricted to the acknowledged leaders, should be designated 'University/National laboratories.' They should be distributed geographically to cover different parts of the ocean and should be provided with adequate facilities for undertaking global deep ocean programs in basic science. Their facilities should be available to scientists at other universities and Federal laboratories for related basic science activities. They should be accorded adequate institutional support for maintenance and operation, and in turn should commit themselves and their facilities to serve needs of scientific groups affiliated with other institutions. Such an institutional arrangement will insure that the Nation's leading oceanographic institutions will be provided adequate resources and support to insure their continued health and vigor."
- "A network of estuarine and coastal zone research institutions should be established in association with appropriate academic institutions to undertake the basic and applied research on estuarine processes so that state and local governments can have information on which to base rational management procedures. These facilities need not be large in size but should have adequate facilities and staff sizes exceeding the critical limit to maintain stable programs. Their activities should be supported under the Sea Grant College Program."
- "Federal laboratories should be strengthened by moving in the direction of fewer but stronger laboratories adequately funded and staffed with even closer affiliation with academic institutions. Steps should be taken to provide an atmosphere in these laboratories conducive to attracting first rank scientists by providing the necessary flexibility at the scientific leadership level."
- "Many marine functions of existing agencies and bureaus should, wherever possible, be consolidated to improve the effectiveness of the Government's participation in a National marine program."
- "The Federal Government should initiate in the near future a program to assure development of basic multipurpose technology that will enhance the capability of a broad spectrum of users to perform useful work on and in the oceans."
- "Person-to-person contacts should be encouraged between groups working in related technological fields. Such contacts could be achieved through contract programs, special information exchange programs, and reciprocal arrangements with industry, government, and the academic community whereby their scientists and engineers would be exchanged."

- "Establishment within the Department of Defense of a strong primary mission in undersea technology to meet present and future threats."
- "The Commission recommends that the Navy maintain and, as required, expand its broad program of oceanographic research, in particular its underwater acoustics research program."

C. Review of Present Federal Marine Laboratories

1. General Comments on Nondefense Federal Laboratories

As evidenced by their recommendation for selective consolidation of marginal laboratories into a small number of stronger centers, the Commission clearly favored fewer, stronger, and more adequately staffed and equipped Federal laboratories. While the Commission was indefinite as to which laboratories they judged to be "marginal," it is apparent that the Commission was principally concerned with the ability of the many small nondefense Federal laboratories to support the statutory responsibilities of their parent agencies.

The Panel shares this concern and strongly supports the position that there is an immediate need for well-rounded, well-equipped, and well-staffed Federal research centers which have organic capability to employ a systematic approach to the conduct of research primarily related to the missions of their parent agencies. It is to be noted that there is no universally accepted standard for the critical or optimum size of a Federal or any other type of laboratory. The situation is further complicated in the area of estuarine and coastal zone research where, because of the highly local nature of the problems, it may be best not to coalesce all small laboratories within a given regional area into one center.

In order to provide a better basis for evaluating the nondefense Federal laboratories, the Panel has outlined below the present laboratory structure for various Federal agencies, that maintain such laboratories to support their missions.

2. Department of the Interior Marine Laboratories

a. Background

Of all the nondefense Federal agencies, the Department of the Interior has the largest interest in the coastal zone. Since its creation more than 120 years ago, the Department has slowly evolved from the role of general housekeeper for the Federal government to that of the "custodian of the Nation's natural resources." Under the Defense Procurement Act of 1950, as amended, the Secretary of the Interior was delegated responsibilities relating to petroleum and natural gas, solid fuels, electric power, fishery commodities or products, and metals and minerals.

Today the Department's geographical responsibilities include the entire continental United States and lands within the Arctic Circle. Its marine-related responsibilities include the custody of 750 million acres of lands, the conservation and development of mineral and water resources, the conservation, development, and utilization of fish and wildlife resources, the coordination of Federal and State recreation programs, the prevention, control, and abatement of pollution of the Nation's water resources, and the management of hydroelectric power systems.

It is apparent that the Department of the Interior combines the Federal government's major responsibilities for the development, use, and management of the living resources of the sea with the responsibilities for marine mineral exploration, recreation, and

water quality and supply. Representative of these responsibilities is the fact that Interior's budget for ocean affairs constitutes about 35 percent of the total Federal civilian effort in marine activities.

b. Mission and Objectives

Succinctly stated, the basic mission of the Department of the Interior is to manage, conserve, and develop the natural resources of the United States, both in the ocean as well as on the land. In carrying out its mission in marine resources, the Department's objectives fall into the following four principal programs:

(1) Fishery program objectives

- Increase the net contribution of living marine resources to the national economy
- Improve the economic status of people in the fishing industry
- Supply the growing and diversified demands of the American people for fish and shellfish products efficiently and economically
- Bring more of the world's living aquatic resources into economic commercial production to benefit all mankind.
- Develop and protect the marine game fish resources
- Increase man's understanding and control of living aquatic resources and their environment

(2) Marine mineral program objectives

- Provide the necessary information and analysis of the geologic framework of the continental margin of the United States
- Assess the resource potentials of the continental shelf and the deep sea floor
- Assist private industry in developing technology for mining placer and lode resources of the seabed

(3) Marine recreational program objectives

- Provide and preserve public access to the shoreline
- Develop an understanding of the socioeconomic aspects of outdoor recreation
- Develop and improve the recreational potentials of the ocean
- Develop a systematic, continuing survey of catch and fishing sport in the marine recreational fisheries

(4) Marine water resource program objectives

- Maintain high water-quality standards for multiple use of the ocean environment

- Develop and perfect a practical, low-cost, large-scale desalting technology
- Improve water-quality monitoring and data collection
- Improve understanding of the effects of specific pollutants on water quality and the living resources
- Improve knowledge of the economics of various uses of the marine environment.

c. Organization

(1) Assistant Secretary for Fish and Wildlife, Parks, and Marine Resources.

The recently created position of Assistant Secretary for Fish and Wildlife, Parks, and Marine Resources discharges the duties of the Secretary with respect to the development, conservation, and utilization of the fish, wildlife, marine, and national park resources of the Nation. The Assistant Secretary exercises direction and supervision over the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife, which comprise the United States Fish and Wildlife Service, the National Park Service, and the Office of Marine Resources.

(2) Office of Marine Resources

The Office of Marine Resources was created to advance and coordinate the Department's marine resource policies, programs, plans, and requests for legislation. This Office serves as the focal point for the Department's interacting with Federal, State, and local governmental agencies, international organizations, private industry, the scientific and academic communities, and the general public.

(3) Principal Bureaus and Offices with Marine Responsibilities

Rapid proliferation of marine science programs in the Federal government since World War II has been accompanied by similar growth in Interior. The following 12 bureaus and offices now have marine responsibilities: Bureau of Commercial Fisheries, Bureau of Sport Fisheries and Wildlife, National Park Service (all under the Assistant Secretary for Fish and Wildlife, Parks, and Marine Resources); Geological Survey, Bureau of Mines (under the Assistant Secretary for Mineral Resources); Bureau of Land Management, Office of Oil and Gas, Bureau of Outdoor Recreation (under the Assistant Secretary for Public Land Management); Office of Saline Water, Office of Water Resources Research, and Federal Water Pollution Control Administration (under the Assistant Secretary for Water Quality and Research); and the Office of the Secretary (see Table 1).

d. Physical Facilities

The Department has an array of laboratories, vessels, and other facilities strategically located along the sea coasts and around the Great Lakes (Fig. 1 and Table 2). These range from well-known laboratories, such as the Bureau of Commercial Fisheries' Biological Laboratory at Woods Hole, Massachusetts, to the recently completed Bureau of Sport Fisheries and Wildlife Laboratory in Narragansett, Rhode Island. Still other laboratories are authorized but yet to be funded. In addition, the Department operates a number of field offices supporting marine mineral research (Geological Survey and Bureau of Land Management) and a large assortment of outdoor recreation facilities (national parks, national seashores, and national monuments), plus thousands of acres of coastal wildlife refuges.

Table 1
Marine Interests of the Bureaus and Offices in the Department of the Interior
(See legend below for explanation of abbreviations)

NON-LIVING RESOURCES

- sea bottom delineation and extraction (BM, GS)
- sea water extraction (OSW, FWPCA)
- mineral economics (BM, OOG)

LAND MANAGEMENT

- exploration and leasing (GS, BLM)
- exploitation (GS, BM)
- recreation (NPS, BSWF, BLM, BOR)
- classification—use benefit determinations (BLM, GS, NPS, FWPCA)
 - for specialized uses (BLM, OS, NPS)
- ocean resources economics (BLM)
- underwater and shoreline natural area perpetuation (NPS, BSWF)

TECHNOLOGY

- submersibles (BCF, BM, BSWF, GS, NPS)
- drilling and sampling techniques (GS, BM)
- EROS, buoys and other data collectors (GS, BCF, BSWF, NPS, FWPCA)
- data collection and distribution (All Bureaus and Offices)
- environmental monitoring (BCF, FWPCA, GS, BSWF, NPS)

GEOLOGY

- structure (GS)
- geologic mapping (GS)
- determination of mineral potential (GS, BM)
- determination of geological engineering characteristics (GS)

WATER

- behavior, currents, temperature (GS, BCF, BSWF, FWPCA)
- quality (FWPCA)
- hydraulics (GS, FWPCA)
- tidal and thermal energy (GS)
- supply (GS, OSW)
- research (OWRR, OSW, FWPCA, BCF)

LIVING RESOURCES

- life cycle and ecology (BCF, BSWF, NPS)
- location and migrations (BCF, BSWF, NPS)
- control and augmentation (BCF)
- resource assessment (BCF, BSWF)
- management (BCF, BSWF, NPS)
- foods (BCF)
- underwater and shoreline natural area perpetuation (NPS, BSWF)
- recreation (BOR, NPS, BSWF, FWPCA)
- fishery economics (BCF)

Legend:

- GS - Geological Survey
- BM - Bureau of Mines
- NPS - National Park Service
- OSW - Office of Saline Water
- BSWF - Bureau of Sport Fisheries and Wildlife
- FWPCA - Federal Water Pollution Control Administration
- OWRR - Office of Water Resources Research
- BCF - Bureau of Commercial Fisheries
- BLM - Bureau of Land Management
- BOR - Bureau of Outdoor Recreation
- OS - Office of the Secretary
- OOG - Office of Oil and Gas

Table 2
Department of the Interior
Major Ships Engaged in Oceanographic Work

| | Length (feet) | Draft (feet) | Beam (feet) | Displ. Tonnage | Complement | | Source | Built | Comm. by Agency | Mission |
|---|------------------|-----------------|----------------|-------------------|------------|---------|--------------------------|--------------|-----------------------|---|
| | | | | | Crew | Tech. | | | | |
| A. Bureau of Commercial Fisheries | | | | | | | | | | |
| Albatross IV | 187 | 15 | 32 | 1,088 | 19 | 12 | New | 1963 | 1963 | Fishery Oceanography and Patrol Work |
| Charles H. Gilbert | 123 | 11 | 21 | 383 | 11 | 5 | New | 1952 | 1952 | |
| David Starr Jordan | 171 | 11 | 37 | 846 | 22 | 13 | New | 1965 | 1966 | |
| George B. Kelez | 176 | 12 | 32 | 936 | 12 | 6 | Conversion | 1944 | 1963 | |
| John R. Hanning | 86 | 9 | 22 | 147 | 7 | 2 | New | 1950 | 1950 | |
| Miller Freeman | 216 | 18 | 42 | 1,782 | 26 | 10 | New | 1967 | 1967 | Fishery Oceanography Fishery Oceanography Fishery Oceanography Fishery Oceanography Fishing Gear Res. |
| Murre II | 86 | 9 | 24 | 250 | 4 | 5 | Conversion | 1943 | 1949 | |
| Townsend Cromwell | 158 | 10 | 33 | 652 | 13 | 7 | New | 1963 | 1964 | |
| Undaunted | 143 | 14 | 33 | 760 | 15 | 12 | Conversion | 1944 | 1965 | |
| George M. Dowers | 73 | 8 | 22 | 120 | 4 | 6 | New | 1955 | 1955 | |
| Delaware II | 155 | 12 | 30 | 680 | 14 | 6 | New | 1968 | 1968 | Fishing Gear Res. Fishing Gear Res. Fishing Gear Res. Fishing Gear Res. Cargo ship serving Pribilof Islands seal management program |
| John N. Cobb | 93 | 9 | 25 | 250 | 7 | 4 | New | 1950 | 1950 | |
| Oregon | 100 | 10 | 26 | 410 | 10 | 5 | New | 1946 | 1946 | |
| Oregon II | 170 | 13 | 34 | 906 | 14 | 10 | New | 1967 | 1967 | |
| Pribilof | 222 | 19 | 51 | 1,893 | 19 | — | Conversion | 1954 | 1964 | |
| B. Bureau of Mines | | | | | | | | | | |
| Cripple Creek Virginia City | 65 205 | 6-1/2 15 | 18 39-1/4 | 95 1,235 | 3 20 | 7 20 | Conversion Conversion | 1952 1943 | 1964 1966 | Marine Mining Marine Mining |
| C. Bureau of Sport Fisheries and Wildlife | | | | | | | | | | |
| Dolphin | 107 | 12 | 25 | 400 | 9 | 7 | Conversion | 1953 | 1964 | Marine game fish research |
| D. Federal Water Pollution Control Administration | | | | | | | | | | |
| Clean Waters | 65 | 6 | 17 | 39 | 1 | 6 | New | 1967 | 1967 | Water quality surveillance, training, and research Servicing water-quality monitoring network |
| W. H. Hutton | 50 | 5 | 13 | 25 | 1 | 4 | Conversion | 1938 | 1963 | |
| E. Geological Survey | | | | | | | | | | |
| Polaris | 96 | 7 | 20 | 57 | 5 | 8 | Conversion | 1927 | 1967 | Marine Geology |

High seas research vessels total 21 and run the gamut from converted barges to modern research vessels, such as the R/V MILLER FREEMAN and the R/V OREGON II (Table 2), which were designed for specific missions of fishery oceanography in the North Pacific and exploratory fishing in the Gulf of Mexico and Caribbean. Such vessels, along with personnel from their associated bases and laboratories, cooperate in many inter-agency oceanographic programs, such as BOMEX, EASTROPAC, and the Indian Ocean Expedition.

Although the Department could accommodate a considerable expansion of program activities at present and authorized marine research facilities, the laboratories are not located so collectively as to allow maximum efficiency of use, nor are they all of optimum size. Diverse management and political expediency in the past have led Interior laboratories to serve such single missions as fishery research (sport or commercial) pesticide research, geological investigations, marine ecology, and water pollution control. A study is proposed that will state long-term laboratory and facility requirements and policies for laboratory location and administration. Preliminary steps are under way to explore occupation of joint facilities. The Bureau of Commercial Fisheries has already taken initial steps to combine several of its small laboratories into a Center of Excellence for Estuarine Studies.

3. Department of Commerce Marine Laboratories. Environmental Science Services Administration

a. Background

The Environmental Science Services Administration (ESSA) of the Department of Commerce was established in 1965 through the consolidation of the Coast and Geodetic Survey, the Weather Bureau, and the Central Radio Propagation Laboratory of the National Bureau of Standards.

ESSA consists of staff offices and five major components. The latter are: the Environmental Data Service, the Weather Bureau, the ESSA Research Laboratories, the Coast and Geodetic Survey, and the National Environmental Satellite Center. The field organization that was formally a part of the Weather Bureau and the Coast and Geodetic Survey remains essentially intact.

b. Mission

The mission of ESSA is to describe, understand, and predict the state of the oceans, the state of the lower and upper atmosphere, and the size and shape of the earth, in order to further the safety and welfare of the public, enhance and improve the Nation's economy, and assist those Federal departments concerned with the national defense, the exploration of outer space, and the management of natural resources.

c. Functions and Activities

ESSA conducts comprehensive programs with respect to meteorology, climatology, hydrology, surveying, cartography, oceanography, terrestrial and space investigations, electromagnetic wave propagation, electromagnetic properties of the atmosphere, telecommunications services, and other related activities within the special competence of ESSA.

Functions and operations of ESSA include basic and applied research, observations, processing and dissemination of forecasts, warnings, and information about the state of the oceans and inland waters, the upper and lower atmosphere, the space environment, and the earth.

d. Assistant Secretary for Science and Technology

The Department of Commerce has a single top-level executive, the Assistant Secretary for Science and Technology, who, among other duties, has cognizance over all the research and development carried out within the Department. In addition to ESSA, the following operating units of Commerce report to him: National Bureau of Standards, Patent Office, Office of State Technical Services, Office of Standards Policy, and Office of Telecommunications.

e. ESSA Marine Laboratories

Of the 12 principal ESSA research facilities, the following constitute the major marine laboratories:

(1) Atlantic Oceanographic and Meteorological Laboratories (AOML).

These laboratories consist of the following component laboratories all located in Miami, Florida: Marine Geology and Geophysics Laboratory, Physical Oceanography Laboratory, Sea-Air Interaction Laboratory, the National Hurricane Research Laboratory, and the Experimental Meteorological Laboratory. The objective of these laboratories is to increase knowledge and provide better understanding of the Atlantic Ocean, Gulf of Mexico and Caribbean Sea, studying their influences and interactions with the physical environment for extending the marine services and operations of ESSA, and application to national needs for improvement of oceanographic and tropical meteorological investigative techniques and instrumentation. Hurricane research was recently incorporated within AOML. Principal research activities are conducted within the following task areas: Structure and motions of the ocean; ocean basin characteristics; sea-air interaction; and hurricane genesis, movement and dissipation.

(2) Pacific Oceanographic Laboratories (POL).

The Pacific Oceanographic Laboratories located in Seattle, Washington, are staffed by marine geophysicists and physical oceanographers. Included within the POL is a joint oceanographic group with the University of Washington in Seattle, Washington, and a joint Tsunami research effort with the University of Hawaii at Honolulu, Hawaii. The objectives of these laboratories are to increase knowledge and provide better understanding of the Pacific Ocean and adjacent regions and their influences on or interactions with the physical environment. The facilities also extend the marine service operations of ESSA and provide for the improvement of oceanographic investigative techniques and instrumentation. Liaison is maintained with the scientific community and other national and international organizations in oceanography and related sciences. Principal research activities are conducted within the following task areas: Structure and motions of the ocean, ocean basin characteristics, and Tsunami research.

(3) Other Principal ESSA Coastal Facilities.

These include: Environmental Data Services and the National Environmental Satellite Center, located in Washington, D.C.; and the two ship operating bases operated by the Coast and Geodetic Survey—the Atlantic Marine Center, Norfolk, Virginia and the Pacific Marine Center, Seattle, Washington.

4. Department of Transportation Marine Laboratories. Coast Guard

a. Mission

The Coast Guard has been involved in ocean science for more than a century. Its statutory mission in oceanography is stated in Article 94, Title 14, U.S. Code as:

"The Coast Guard shall conduct such oceanographic research, use such equipment or instruments, and collect and analyze such oceanographic data, in cooperation with other agencies of the Government or not, as may be in the national interest."

b. Coast Guard Marine Laboratories

(1) Coast Guard Oceanographic Unit (CGOU)

The CGOU is the principal marine laboratory of the Coast Guard, directly employing about 60 oceanographers and technicians and utilizing three vessels, the ROCKAWAY, the GLACIER, and the EVERGREEN, as principal oceanographic platforms. In addition to the staff of the unit, there are about 15 technicians and oceanographers on the ROCKAWAY and about 80 technicians stationed on 40 other cutters. These cutters are equipped for oceanographic sampling.

The CGOU's mission is to exercise cognizance over the Coast Guard oceanographic program. This includes functions such as data collection, processing, and dissemination. The Unit is responsible for liaison and cooperation with other agencies and is concerned with instrument development and calibration, and oceanographic techniques and procedures. In general, it conducts oceanographic research in support of the statutory functions of the Coast Guard in furtherance of the national oceanographic effort. Finally, it provides oceanographic support of the operation of the International Ice Patrol, and it conducts studies of ice and current conditions in accordance with the International Conference on Safety of Life at Sea and 46 USC 783.

Oceanographic operations at the Coast Guard Oceanographic Unit include:

- Data collection, processing, and transmission from United States Weather Ships on a continuous real-time basis
- Physical oceanographic work by Coast Guard icebreakers. Current studies include the physical oceanography of Baffin Bay and Davis Strait, Chukchi Sea, and the Weddell Sea.
- Coastal oceanographic monitoring by selected Coast Guard ships, lightships and stations, and coastal airborne infrared radiometry
- Search and Rescue research into the drift and detection of survivors and the improvement of search prediction methods
- Oceanographic operations and research of the International Ice Patrol
- Participation in large national oceanographic efforts, such as ICITA, EASTROPAC, and BOMEX.

(2) National Data Buoy Development Project

The National Data Buoy Development Project was established to develop a national capability to implement networks of unmanned, automatic, environmental data buoys in coastal North American, deep ocean, estuarine, and Great Lakes areas. The project consolidates national planning and development efforts. As a starting point, it uses the several underfunded, uncoordinated data buoy programs that were previously begun by individual agencies of the Federal government. The project directly employs a staff of 18 ocean scientists, engineers, and technicians, and 10 administrative support personnel for in-house operations.

Present activities of the project include:

- Systems planning, including the publishing of a Preliminary Concept Formulation Summary, a tentative Specific Operational Requirement, and two engineering studies of alternative technical approaches to meet operational requirements
- Participation in the Navy North Pacific (NORPAC) buoy testing program in order to obtain HF vs satellite relay comparison data
- Commencement of initial mooring, sensors, and power supply studies and investigations
- Direction and supervision of several out-of-house contractual investigations of systems engineering, communications problems, sensor development, automation, mooring systems, and systems analysis.

(3) Field Testing and Development Center (FTDC)

The FTDC, located at Curtis Bay, Maryland has the mission to conduct field tests under controlled service conditions and to develop warning prototypes of various devices being considered for servicewide use. The Center employs a technical and support staff of 27 people.

(4) Coast Guard Academy

The Coast Guard Academy located at New London, Connecticut operates a small laboratory with a staff of two oceanographers and one technician. This staff works with about 40 to 50 cadets. The principal mission of the laboratory is to train cadets who are working toward an Ocean Science degree. In addition, the laboratory is also involved in an on-going study of the Niantic River estuary. The cadets participate in the acquisition, processing, and analysis of oceanographic data from the laboratory's 24-ft research boat and from cutters and icebreakers on summer cruises.

5. Other Nondefense Federal Marine Laboratories

a. Smithsonian Institution

(1) Background

The Smithsonian Institution is a unique organization whose functions are dual, being both private and governmental. As a legal governmental organization, the Smithsonian Institution is one of the 32 independent offices and establishments of the Government of the United States, which include of particular interest to this Panel, the Atomic Energy Commission, the Federal Maritime Commission, the National Aeronautics and Space Administration, and the National Science Foundation.

The Smithsonian Institution was created by an act of Congress approved in 1846. In 1829, James Smithson bequeathed his fortune to the United States to found, at Washington, under the name of the "Smithsonian Institution" an establishment for the "increase and diffusion of knowledge among men."

As a Federal agency, its establishment has as members the President of the United States, the Vice President, the Chief Justice, and the 12 members of the President's Cabinet. It is governed by a Board of Regents consisting of the Vice President, the Chief Justice, three Members each of the United States Senate and the House of Representatives, and six citizens of the United States appointed by joint resolution of Congress. The

Secretary of the Institution is its executive officer and the director of its activities. As a Federal agency, the Smithsonian is funded by Federal appropriations and administers various Federal programs placed under its control by Congress. The first Federal appropriation for Smithsonian operation took place in 1877.

The Smithsonian Institution itself is a private, nonprofit corporation. It receives and administers contracts and grants and accepts gifts and bequests from both private and public sources and, administers these activities in its capacity as a private organization.

(2) Functions and Activities

To carry out Smithsonian's mandate, the Institution performs fundamental research; publishes the results of studies, explorations, and investigations; preserves for study and reference about 62 million items of scientific, cultural, and historical interest; maintains exhibits representative of the arts, American history, aeronautics and space exploration, technology, and natural history; participates in the international exchange of learned publications; and engages in programs of education, along with natural and international cooperative research and training.

Among its many reference collections are the vital collections of catalogued marine organisms and fossils in the National Museum of Natural History which have made the Smithsonian the study and reference center for the leading marine biologists of the world.

(3) Marine Laboratories

The Smithsonian operates three facilities which the panel considers important among the marine laboratory resources of the Federal government. These are:

The Smithsonian Tropical Research Institute, located on Barro Colorado Island in the Panama Canal Zone. This Institute conducts a wide variety of tropical research programs and operates two marine biology laboratories, one on the Atlantic side of the Isthmus at Galeta Island and the other at Fort Amador on the Pacific side. In addition to the marine research conducted in the littoral waters of two oceans in Panama, the Institute's scientific staff conducts research in other parts of Central and South America, the Pacific, Asia, and Africa, where comparative studies are clarifying the distinctive biological role of the tropics.

The Chesapeake Bay Center for Field Biology, Edgewater, Maryland is a major component of the Smithsonian established in 1965 on 700 acres of waterfront lands on the eastern shore of the Chesapeake Bay through the generosity of private individuals and foundations. This new Center is conducting research particularly important to the problems of the coastal zone including such areas as: water quality; productivity of plankton in the Bay and rivers; distribution and abundance of native and introduced aquatic vegetation and their diseases; fish populations, varieties, distribution, rate of growth, and predator-prey relationships; ecology of aquatic birds; and other coastal zone and estuarine research oriented towards both land and water ecosystems and their interrelationships.

The Oceanographic Sorting Center, Washington, D.C., which was established in late 1962 to act as a service organization to the scientific community in receiving, sorting, recording, and distributing marine biological and geological specimens. Initial sorting is done by technician-level personnel, and the sorted collections are shipped to specialists located throughout the world, such as the Mediterranean Marine Sorting Center in Tunisia. This procedure permits the effective use of the small number of highly skilled taxonomists. The Center is supported both by direct appropriation and through contracts with several Federal agencies, including the Department of Interior, the National Science Foundation, and the Office of Naval Research.

b. Department of Health, Education, and Welfare (DHEW)

(1) Background

The Department of Health, Education, and Welfare was created by Reorganization Plan 1 of 1953, which abolished the Federal Security Agency and transferred all functions to the new organization. DHEW was established for the purpose of improving the administration of those agencies of the Government, the major responsibilities of which are to promote the general welfare in the fields of health, education, and social security.

Within the DHEW is the Public Health Service, which had its origin in act of 1798 authorizing marine hospitals for the care of American merchant seamen. Subsequent legislation and Presidential Reorganizational Plans have vastly broadened the scope of its activities. Today, the Public Health Service consists of three operating agencies: the Consumer Protection and Environmental Health Service, the Health Services and Mental Health Administration, and the National Institutes of Health. Unified direction of these agencies is the responsibility of the Assistant Secretary (Health and Scientific Affairs) whose principal deputy is the Surgeon General of the Public Health Service.

(2) DHEW Marine Laboratories

Within the Department of Health, Education, and Welfare, the Public Health Service has four laboratories engaged in marine sciences research, and also supports a broad spectrum of marine-oriented research through research grants. These four in-house laboratories, which are operated by the Consumer Protection and Environmental Health Services's Bureau of Water Hygiene, are the Northeastern Water Hygiene Laboratory, Narragansett, Rhode Island; the Gulf Coast Water Hygiene Laboratory, Dauphin Island, Alabama; the Northwestern Water Hygiene Laboratory, Gig Harbor, Washington; and the Cincinnati Water Hygiene Laboratory, Cincinnati, Ohio.

The prime responsibility of the laboratories is to provide the technical and scientific competence for measurement and assessment of the biological, chemical, and physical factors that determine the environmental characteristics of water when it is used for human consumption, recreation, and food production.

(3) Other DHEW Marine Research Programs

In addition to the above in-house research programs, it is to be noted that the Consumer Protection and Environmental Health Service supports over \$1 million in research grants annually in marine science areas related to its programs, including such areas as seafood and seafood poisons, safety of SCUBA diving, pesticides in seafood, ocean disposal of solid wastes, and microbiology of the marine environment.

The National Institutes of Health supports a multimillion-dollar research grants program in areas related to the marine environment. Studies include such subjects as barometric decompression, marine physiology, aquatic biology, mode of action of marine toxins, diseases and behavior of marine organisms, pathophysiology of drowning, communications in deep sea diving, and related subjects.

6. General Comments on Defense Laboratories

The marine science programs under the Department of Defense generally fall into two categories. The principal DOD programs are those of the Department of the Navy which are principally oriented towards maintaining the capabilities of our naval forces to conduct their Presidential and OSD assigned missions related to national defense. The

second category consists of those long-established functions of the U.S. Army Corps of Engineers related to public works in the coastal and inland waters of the United States.

As compared to the non-Defense laboratories, the DOD laboratories which support the above Army and Navy programs are "big business," albeit nonprofit, in terms of men, money, and materials. For example, well over one-half of the Federal marine science program is sponsored by the Navy and many of the Navy's programs are carried out by the large in-house laboratories. These laboratories range in size from the Naval Civil Engineering Laboratory with about 370 personnel and a total funding of approximately \$8 million, to the Naval Ship Research and Development Center with about 3,500 personnel and a total funding of over \$100 million.

7. Coastal Engineering Laboratories and Activities of the U.S. Army Corps of Engineers

a. Background

In addition to its military mission, the Congress has given the Corps of Engineers certain Civil Works missions dealing with improvement of channels for navigation, flood control, and protection and restoration of ocean shores. Some \$1.2 billion is spent annually on this program, of which some \$200 million is spent on projects in the coastal areas of the United States, including the Great Lakes. The Corps has a research program to support this Civil Works mission which is carried out by three Corps laboratories. Before describing these laboratories, however, it would be well to describe the overall Corps' organization in order to put the research program in its proper context.

b. The Corps Districts and Project Reports

The Civil Works design, construction, operation, and maintenance program of the Corps is carried out by an organization of 45 Districts reporting to 9 Divisions around the country. Twenty-two of these Districts border on our coastline and are engaged in studying and analyzing the coastal processes to the extent that they influence the various Corps projects being studied, constructed, or maintained in that area. Their work is not research, but the practice of engineering. Nevertheless, these Districts collect a vast amount of tidewater and coastal physical data which appears in their design studies of various projects.

It is of some interest to note that the project studies are made by the Corps only on specific instruction by Congress. In effect, this means that the Corps' Districts have no authority to collect and analyze general coastal data. Their studies are made only on specific instructions from Congress to study a particular area for a particular purpose.

In preparing its report on a particular project, the Corps District contacts all interested public agencies—Federal, State, and local—to determine their views on the project and to get their input on such matters as effects of the proposed project on fish and wildlife and on water quality.

Public hearings are held which allow persons and organizations to express their thoughts concerning the proposed project. A draft of the final report is circulated to the interested public agencies before completion, and any conflicts of interest are worked out, if possible, before the report is sent to Congress.

c. Corps' Laboratories

In order to enable the Corps to fulfill its mission of design, construction, operation, and maintenance of this \$200-million-a-year coastal works program, the Corps carried out a program in coastal engineering research. This research program

is shown in the Marine Council report to be \$8.4 million for FY 69; of this total about one-half is direct R&D appropriations and one-half is spin-off R&D from the design, construction, and operation of coastal area projects by the Corps of Engineers.

The Corps coastal engineering research mission is carried out principally by the Coastal Engineering Research Center in Washington, D.C., the U.S. Lake Survey District in Detroit, Michigan, and the Waterways Experiment Station in Vicksburg, Mississippi. The largest R&D appropriation in coastal engineering is to CERC with the Lake Survey second. WES does not receive a direct R&D appropriation but undertakes specified R&D work on request with funds supplied by the Office of the Chief of Engineers or by CERC.

d. Coastal Engineering Research Center

The research program at CERC is divided into ten project categories as follows:

1. Wave Action in Coastal Waters
2. Shore Processes
3. Tides and Surges
4. Inlet Dynamics
5. Estuary Dynamics
6. Coastal Works Evaluation
7. Functional Design of Coastal Works
8. Structural Design of Coastal Works
9. Coastal Construction Techniques
10. Environmental Data Collection.

About 35% of CERC's R&D funds is spent in-house by its staff of 93 persons in its own laboratory wave tanks and field experiments. The other 65% is spent on R&D contracts with other agencies, universities, and private firms. The results of research are published in a Technical Memorandum series, which is given wide distribution. The staff of CERC also acts, on request, as consultants to field offices of the Corps and other government agencies.

e. Lake Survey

The Lake Survey R&D program involves a study of the physical limnology, water movements, water quality, and hydrology of the Great Lakes. Most of its funds are spent in-house. In addition to its R&D mission, the Lake Survey prepares and distributes the hydrographic charts of the Great Lakes and operates the Great Lakes Data Center. Its duties involve considerable contact with agencies of the Canadian government having an interest in the Great Lakes.

f. Waterways Experiment Station

As stated earlier, WES has no funds appropriated directly to it for research. Instead, it undertakes specified research on commission from the Office of the Chief of Engineers or CERC. The principal R&D activities of WES in the coastal engineering field have been in the design of rubble-mound breakwaters and jetties, the intrusion of salt water into coastal estuaries, the shoaling processes in estuaries, and the mechanics of coastal inlets. In addition to its R&D work, a much larger mission of WES is the study of specific field problems by means of small-scale hydraulic models. Although these model studies frequently have an R&D spin-off, they are not considered to be part of the R&D effort and are funded by project funds instead of R&D funds.

g. Ecological Effects

As might be suspected, one of the most difficult things for the Corps to determine accurately is the effect of certain coastal projects on the ecology of the adjacent area. Project study funds appropriated by Congress are frequently not sufficient to enable a long-term study of the ecology to be undertaken. Thus, reliance must be placed largely on the existing knowledge of other agencies working in this field. It would seem that one present need is for better detailed definitions of the ecology of our various coastal areas, coupled with a better understanding of the interrelation of the ecology with the physical and chemical properties of the water mass. Only in this way can we improve our ability to estimate reliably in advance the quantitative effects of proposed engineering work on the ecology of the surrounding coastal area.

h. Summary

The Corps R&D program in coastal engineering is a mission-oriented program and extends from studying the fundamentals of shore processes to the development of design criteria for coastal structures. The area of interest extends from the inshore head of tidewaters to the depths offshore in which engineering structures are constructed. Although greatly concerned with the effects of proposed engineering works on the ecology of coastal areas, the Corps R&D program is not geared to meet its own needs in this type of study completely. The Corps must rely heavily on others to develop the detailed knowledge needed in this field of activity.

8. Navy Laboratories

a. Background

Marine science and technology have played lead roles in the development of the U.S. Navy since the Continental Navy fought in the American Revolution. The first American Congress authorized experiments in ships and guns in 1789. Research programs in the fields of magnetism, meteorology, and astronomy were conducted in the Naval Observatory in 1830, 14 years before the Observatory opened formally in 1844. Through its constantly evolving scientific and technical efforts, the Navy has managed to weather the frequent storms of technological revolution during the last two centuries. Today the Navy is still the principal supporter of oceanic research and development with more than one-half of the total Federal marine science program being funded with monies appropriated for the Navy. While its programs must be oriented towards national security, many of the Navy's programs have provided vital scientific knowledge and sound engineering technology. The results of these programs have given invaluable support to other Federal agencies, to academic institutions, and to the ocean-oriented industry.

The Navy has continued to advocate the need to maintain in-house scientific and technological capabilities. The Navy espouses the view that its success in marine science can be attributed in large measure to its long-standing policy of maintaining numerous Navy laboratories. This year, one of the principal Navy laboratories, the Naval Underwater Weapons Research and Engineering Station, Newport, Rhode Island, celebrates its centennial. At least eight of the present Navy laboratories can trace their earliest beginnings in marine science and technology to the more languorous days before World War II, and three of these laboratories had their founding before the Great White Fleet circumnavigated the world in 1907.

While the above remarks imply long periods of stability in the evolution of the Navy laboratories, such is not the case. It can be generally stated that, under the stimuli of frequent wars and increasingly complex technological revolutions, the Navy laboratory

community has endured more change than it has enjoyed stability. By way of example, the following brief resume sketches the evolution of the current Naval Material Command laboratories since World War II.

b. Evolution of the Present Navy Material Command Laboratories since WWII

Following World War II, the Navy found itself with a large and diverse mixture of research development, test, and evaluation facilities (RDT&E), many of which had sprung up to meet the immediate needs of global war with little thought given to postwar requirements. Since their inception, all of these RDT&E facilities had operated under the venerable bureau organization wherein each laboratory reported only to one bureau. Before the formation of the Naval Material Support Establishment in 1963, little corporate direction was exercised in the evolution of the laboratories because the various bureaus enjoyed a semiautonomous state in a loose confederacy that produced the Navy's material needs.

By the early 1960's, the bureau system had fostered a complete Balkanization of research and development into isolated pockets which were almost solely oriented towards the parent bureau's separate role (e.g., aircraft, ships, ordnance, supply, construction). By the 1960's, the already difficult task of designing, developing, constructing, and then integrating the hardware of the separate bureaus into naval systems became extremely complex. The perplexing problems of man-machine interface also began to demand more and more research and development to insure complete system integration. Radical change was required within the Navy laboratory structure in order to bridge the systems gaps and to reduce the Balkanization effect that continued even after the material bureaus were forced into the Naval Material Support Establishment in 1963. Following the major material command reorganization of 1966, the Navy material laboratories were divorced from their parent bureaus and put under the immediate command of the Chief of Naval Material.

In 1967, the Navy commenced its current program of integrating the separate laboratories into centers of excellence which are basically oriented towards solving the technological problems of major warfare systems. As noted in the following chronological sketch, the rate of change in the evolution of Navy laboratories has accelerated rapidly since 1963 and reflects the growing complexity of maintaining national security.

1946 - Establishment of the Office of Naval Research

1955 - The position of Assistant Secretary of the Navy (Research and Development) was created "in order to afford one Assistant Secretary full time duties in the vital area of Research and Development."

1963 - In a major Navy reorganization, the four material support bureaus (then Ships, Weapons, Supplies & Accounts, and Yards & Docks) with their supporting laboratories were located within the Naval Material Support Establishment and placed under the command of the Chief of Naval Material.

1966 - Establishment of a civilian Director of Navy Laboratories (DNL) reporting directly to the Assistant Secretary of the Navy (Research and Development) and coequal with the Deputy Chief of Naval Operations (Development), the Deputy Chief of Staff (R&D) Marine Corps, the Chief of Naval Development, and the Chief of Naval Research

In a second major Navy reorganization, the Naval Material Command was established with six principal subordinate organizations (Commands vice Bureaus). Of major significance to the laboratory community, the 15

principal Navy laboratories were removed from the direct control of the Bureaus. In announcing this reorganization, the Secretary of the Navy stated that he expected this change to "centralize and improve the coordination of RDT&E management."

- 1967 - Implementation of Navy plans to establish centers of excellence capable of prosecuting large systems development. Five large Navy R&D Centers were formed by consolidating existing laboratory facilities as follows:

Naval Ship Research and Development Center, composed of the former David Taylor Model Basin (Carderock, Maryland), Marine Engineering Laboratory (Annapolis, Maryland), and Naval Mine Defense Laboratory (Panama City, Florida).

Naval Weapons Center, composed of the former Naval Ordnance Test Station (China Lake, California) and the Naval Ordnance Laboratory Corona (Corona, California).

Naval Command Control Communications Laboratory Center, composed of the former Navy Electronics Laboratory (San Diego, California) minus its ocean sciences organization. The name of NCCCLC was subsequently changed to Navy Electronics Laboratory Center.

Naval Undersea Warfare Center, composed of the former Pasadena Annex of the Naval Ordnance Test Station (Pasadena, California) plus the ocean sciences component (Underseas Technology Directorate) of the former Naval Electronics Laboratory in San Diego, California. Also included were several auxiliary sites, such as San Clemente Island, of the former Pasadena Annex. Subsequently, the headquarters of the center was moved to San Diego, and the name was later changed to Naval Undersea Research and Development Center. An additional satellite laboratory was recently established in Hawaii.

The scope of the Naval Air Development Center was increased through incorporation within it certain of the former component laboratories of the Naval Air Engineering Center.

- 1969 - In April of this year, the Navy announced the disestablishment of the Naval Radiological Defense Laboratory, the Naval Weapons Center Corona Laboratories, and the Naval Applied Science Laboratory. Key functions of these laboratories are being transferred to appropriate centers and laboratories. The consolidation of the Naval Underwater Sound Laboratory with the Naval Underwater Weapons Research and Engineering Station into a Naval Undersea Research and Development Center for the Atlantic Coast is still under active consideration.

By way of comparison, 15 Navy laboratories existed before the 1966 reorganization, each serving only one bureau. There are now 12 centers and laboratories, all supporting more than one system command. With the three disestablishments mentioned previously, and with the formation of the East Coast Naval Undersea Research and Development Center, the Navy will have further consolidated its Naval Material Command laboratory resources into six major centers of excellence and three laboratories—all serving multiple customers.

c. Marine Science and Technology in Navy Laboratories Today

1. Background

Well over one-half of the Federal marine-science program is sponsored by the Navy, with the principal objective of maintaining and improving the capabilities of our naval forces to conduct their uniquely military missions related to national security. With the growing worldwide interest in the oceans, both as potential areas of sophisticated military operations and as a source of living and mineral resources, the importance of the Navy's marine science and technology programs is steadily increasing. These programs not only contribute to immediate and future naval needs, but also enhance the Nation's global maritime presence and augment national political, economic, technical, and scientific capabilities.

The Navy's Oceanographic Program is currently concentrated in three areas:

- The Ocean Science Program includes the study of the physical, chemical, biological, and geological characteristics of the oceans. Underwater acoustics research in support of the Navy's antisubmarine-warfare program is a major area of concern. Research and development in these areas is conducted under the Chief of Naval Research, utilizing the various in-house Navy laboratories, through contracts with private institutions, universities, and other contractors, and through cooperation with other Federal agencies, such as the Bureau of Commercial Fisheries.
- The Ocean Engineering and Development Program is conducted under the Chief of Naval Development, with responsibility for undersea search, rescue, salvage and construction. Inherent in this program is the necessary development effort required to insure that the best materials, tools, vehicles, habitats, and equipment are available for use in the marine environment. These programs are generally carried out through the Navy's in-house laboratories and by contract to institutions and to the industrial community.
- The Oceanographic Operations Program involves direct support of both naval operating forces and navigators generally through the collection of environmental data by specially equipped ships, submarines, aircraft, and buoys, as well as other devices. The transformation of these data into useful products for Navy use, for other national programs, and, in some cases, for international distribution is a responsibility of the Oceanographer of the Navy.

2. Laboratory Organization for Marine Science and Technology

It is pertinent to note that the formal Naval Oceanographic Program outlined above does not represent the total employment of marine science and technology within the Navy. On the contrary, many of the various professions and skills that have been identified as components of "marine science and technology" are required in significant numbers in the Navy's test and evaluation field activities as well as in the large in-house laboratories. In fact, it may be noted that there is an apparent proliferation of marine science and technology within the in-house laboratories and that the Navy does not have even one of its laboratories designated as "centers of excellence" in these areas.

There are several reasons for this apparent proliferation. First, it is to be expected that at least a limited amount of marine science and technology must be employed in all of the Navy's laboratories, regardless of organizational structure, because of the uniquely marine environment in which all naval systems must be able to operate. The Navy desires to organize its centers of excellence based on warfare systems. However, the spectrum of laboratory requirements is so large and so varied as to defy simple or permanent solution. For example, rational alternatives for laboratory organization based on the numerous Navy requirements would include:

- Warfare areas (e.g., antisubmarine, strike, amphibious)
- Weaponry (e.g., mines, torpedoes, air-launched missiles, naval guns)
- Common platforms (e.g., surface, subsurface, air)
- Common military functions (e.g., communications, command & control, logistics, surveillance)
- Technology (e.g., oceanography, materials, electronics).

With the Navy's broad and varying requirements, it is apparent that it is impossible to organize a laboratory structure that will fit completely into one or even several of the various alternative possible structures. The immediate problem becomes the common management dilemma of attempting to organize a multidimensional problem into only several dimensions. The result of any such attempt is that duplications and gaps are likely, and the final choice of organizational structure must reflect both the priorities of the requirements and the relative difficulties of managing the interfaces. With the growing complexity and costs of weapon systems, priority must be given to managing the system interfaces, and the minor duplications in technologies, such as materials and electronics, must be accepted.

There are also more subtle reasons for the diffusion of marine science and technology capabilities within the Navy. It is not surprising, for instance, that the Navy is subjected to the same political pressures as, say, the Department of Interior. As a result, it has located some of its research and development facilities far afield from the optimum sites. Finally, certain Navy laboratories, like their academic and industrial counterparts, have succumbed to the loudly touted promise of an oceanic bonanza and have, with fond hopes, added "oceanography" to their credentials.

The Panel appreciates the above reasons and is heartened by the recent progress made by the Navy in strengthening its laboratory resources through selective consolidation. Nevertheless, it is the general opinion of the Panel that further consolidation is in order as regards the Navy's marine science and technology programs. For instance, it is noted that there is considerable fragmentation of physical laboratory facilities, as well as divisions in the management effort, of such vital and related Navy programs as man-in-the-sea, deep diving, and undersea medicine. Elements of these programs are dispersed among different bureaus and offices and between widely separated laboratory facilities. Further, it is reported that three costly and scarce hyperbaric chambers may be constructed independently of each other at three different and distant sites.

It is therefore concluded that National oceanic needs and Navy missions would both be better served if the Navy were to concentrate the skills, programs, and facilities for such important ocean science and ocean engineering undertakings in one center. As ocean science and ocean engineering are the prime requisites for underseas warfare systems, it would be most appropriate if this center were an existing center capable of coping with large underseas weapons systems. The Panel further concludes that national and Navy programs would be additionally enhanced if this Navy center were so located as

to permit cooperative efforts between the Navy and one of the National Oceanographic Laboratories or one of the National Oceanographic Research Centers recommended by the Panel in the Panel Findings and Recommendations portion of this report. The advantages of such consolidation and location would include:

- Great potential for increase in efficiency because of concentration in one area of the multidisciplinary scientific, technical, and support skills required for critical mass in these programs.
- Opportunity to reduce costs of such facilities as hyperbaric chambers by combining them into one complex with shared support.
- Proximity and potential for recruiting and exchange of high quality personnel in the academic and professional environment associated with the nationally recognized universities and institutions recommended as National Oceanographic Laboratories as lead laboratories in the Regional Oceanographic Laboratory Centers.
- Mutual availability of special facilities, such as ships, exotic platforms, aircraft, buoys, submersibles, and other major requirements, including instrumented test ranges.
- Proximity of excellent applied engineering support from large Navy center and nearby oceanic oriented industry.

D. Problems Common to Federal Laboratories

1. Background

During the past several decades, the in-house Federal laboratories, both non-defense as well as defense, have been subjected to repeated studies and have been the target of much criticism by the Congress and by their parent departments and agencies. Governmental files and Congressional Records contain literally dozens of studies and hundreds of comments and recommendations on the subject of in-house Federal laboratories. While there are a significant number of outstanding Federal laboratories with long records of achievement, there are also many Federal laboratories whose poor quality justifies the documented criticism. While most of the recommendations of the many studies have been signed off as "implemented," the basic causes of poor quality have not been eliminated but have only taken on new effects. Therefore, in the words of the much-quoted professor, the Panel feels that "this has all been told before but it will have to be told again because apparently nobody listened."

2. Justification for In-House Federal Laboratories

Although less frequently encountered than in the past, one problem common to Federal agencies has been the need to justify in-house laboratories vis-a-vis outside contracts. Today, there is growing recognition that most Federal agencies require in-house scientific and technical competence to carry out their assigned missions and tasks. Outlined below are some of the more commonly accepted reasons for in-house Federal laboratories:

- Dependable source for carrying out the statutory requirements of the Federal government in such functions as inspection and regulation.
- In-house basis for sound decision-making by the Federal government through employment of such techniques as systems analysis.

- Competence to demonstrate feasibility of possible solutions to mission-related problems, as through the manufacture of prototypes.
- Capability to monitor technical work performed within agency or by contract.
- Reliable and stable in-house corporate memory not possible through contract operations.
- Capability to test and evaluate mission related equipment.
- Stimulus for both Federal and civilian agencies in same or similar fields.
- Attraction for top-caliber scientific and technical personnel.
- Training ground for future technical managers and administrators.
- Maintenance of national competence, especially during times of financial retrenchment or in peace.
- Rapid, and often only, response capability to sudden agency problems.
- Sole means of carrying out programs not adaptable, or not acceptable, or not economical for private laboratories, such as sensitive warfare projects or mapping and charting missions.

3. Other Problems Common to Federal Marine Laboratories

The Panel was concerned to observe that many of the problems common to most Federal laboratories appear to be particularly chronic in the various Federal marine laboratories reviewed during the study. These problems, which are by no means new and which are well documented in the many studies mentioned previously, are not insoluble. They will not be solved, however, unless they are recognized and addressed in detail by the highest executive levels in the responsible Federal agencies. The following discussion highlights those problems which the Panel believes to be most debilitating to the Federal marine laboratories.

There is an apparent tendency to treat research-and-development functions in the same manner as any other function in matters of hiring, reductions in force, budget cuts, facilities construction, equipment procurement, travel, and the like. Various critics have aptly dubbed this tendency the "share-and-share-alike-syndrome." This prevalent policy, which should be readily correctable at the top executive level, is probably a cardinal cause behind mediocrity in Federal laboratories. It becomes extremely difficult to recruit and retain top quality personnel under such a policy, particularly in comparison with the pay, prestige, and privileges afforded research personnel in private laboratories.

Too many layers of management often occur between the laboratory director and the decision making level in the parent agency. Numerous Federal laboratories are so buried organizationally as to stifle communication and feedback between key personnel. As a result, certain laboratories simply become invisible in the organization and thus soon ineffectual. In addition, these multiple tiers of management often contain an excess of middle managers who frequently contribute to the "share-and-share-alike syndrome." Related to this problem of layering are the many laboratories which lack a single and visible spokesman who can champion their cause at the top executive level, whenever necessary.

Laboratory directors often lack flexibility in the key matter of controlling certain of his resources. For instance, most of the nondefense laboratory directors lack "discretionary funds" to spend for independent mission-oriented research or for research on national problems which are well within the capability of the laboratory. Operations are greatly hampered by the continuing trend towards overcentralization at the Washington level, as currently evidenced by increasingly detailed reporting requirements, especially in the areas of financial and manpower controls. Finally, an inordinate effort is required at all levels to justify and to acquire new facilities and major equipment, such as large computers.

Manpower controls which operate in isolation to the total workload assigned to a laboratory are often illogical. These controls frequently restrict the director's ability to carry out projects for which he has ample funds. Personnel controls are not only confined to total numbers of permanent employees, but also inhibit the laboratory director in employing temporary employees. Flexibility is further reduced in matters related to distribution of grade levels and average salaries. The cumulative effects of these controls are visible in many laboratories in the form of high average ages of professional personnel, lack of input of recent college graduates, and a serious imbalance in the ratio of support to professional personnel. The latter is particularly common during fluctuations in manpower ceilings, when laboratory directors follow the natural tendency to lay off support personnel when ceilings are reduced and then hire new professionals, particularly recent graduates, when ceilings are increased. One very noticeable effect of this latter problem is the large number of professionals who must perform menial and uneconomical work because of the lack of support personnel.

E. Tropical and Arctic Laboratory Requirements

During the final stages of this study, it was noted by various members of the Panel that no specific requirements had been derived regarding laboratories for tropical and arctic research. There is, of course, certain research being carried out in tropics by the Smithsonian Institution, and arctic research is sponsored by both the Office of Naval Research and the National Science Foundation. Nevertheless, it was generally concluded that additional programs and additional facilities would be mandatory in both areas during the coming decade.

Such programs and facilities could be supported through the Coastal Zone laboratory complex. However, the broad nature of the present and potential problems are such as to warrant the attention of the Federal government. Thus, while the subject of tropical and arctic laboratories was not a specific task of the Panel, it is the opinion of the Panel that the Marine Science Council should address the subject during the next appropriate review concerning general marine science programs.

APPENDIX A

QUESTIONNAIRES TO OCEANOGRAPHIC INSTITUTIONS, UNIVERSITY DEPARTMENTS OF OCEANOGRAPHY AND NATIONAL LABORATORIES

The following series of questions concerning University/National Laboratories and Coastal Zone Laboratories was submitted to the Directors of the major university oceanographic departments and oceanographic institutions.

QUESTIONNAIRE A

1. What do you see as the role, responsibilities, mission, and problems of a University/National laboratory?
2. How would your present method of operation be changed if your institution were to be designated as a University/National laboratory?
3. What do you see as the obligations of the Federal Government in such a relationship?
4. Should the Federal Government fund one or more of the following: ships, facilities, overhead, personnel, new buildings, individual programs, or specific investigators? How would the funding pattern of a University/National laboratory differ from your present Federal sponsorship?
5. What process of review, evaluation, and coordination of your operations would you anticipate if the Federal budget undertook responsibility for the items listed in paragraph 4 above?
6. What do you believe would be the appropriate size of a University/National laboratory? What do you think is the appropriate number of University/National laboratories? Should their location be decided on a geographic basis?
7. What should the requirements be for designation of an oceanographic institution as a University/National laboratory? Of the ten largest oceanographic laboratories referred to on page I 46, Vol. 1, of the Panel Report of the Commission on Marine Science, Engineering, and Resources, which if any should be designated as University/National laboratories? What is the basis for your choice?
8. If the designation of your institution as a University/National laboratory caused your institution to be defined by Congress as a Federal contract research center, would this designation with the attendant funding and ceiling limitations be acceptable to you?
9. As a private university, a State-run institution, or an independent corporation, would the designation of your institution as a University/National laboratory present legal problems? Would a change be required in your charter, enabling legislation, or terms

of incorporation? Would such changes be either possible or acceptable to your institution?

10. Discuss the inadequacies or difficulties that are inherent in your present financial sponsorship. Given your present mix of sponsorship by the Office of Naval Research, the National Science Foundation, and the Atomic Energy Commission and other Federal and non-Federal sources, how would you anticipate the situation would change if your laboratory were to be designated as a University/National laboratory? If you are not so designated, what would you regard as the optimum mix of financial sponsorship for your institution?
11. Congress normally reviews the funding level of Federal programs on an annual basis. Such a review typically requires a justification of the size, scope, and uniqueness of the program in considerable detail. Would you be willing to accept such detailed Federal intervention into your operations?
12. Oceanographic laboratories have a commendable history of forming interinstitutional consortia to tackle large or unusual programs. In your view, has this mode of operation been satisfactory? Does our Nation require greater capabilities or new organizational forms in order to attack "big science types of oceanographic problems"? Would the existence of a University/National laboratory status help our Nation achieve an enhanced capability that is not presently available to undertake large-scale oceanographic ventures?
13. The recommendations of the Commission give the existing Federal in-house laboratories rather short shrift. The Commission's recommendations allude to the need for fewer but stronger Federal laboratories and express concern that federal laboratories do not possess sufficient economy and flexibility. In view of the spectacular scientific success and stature of various components of the Federal laboratory system (e.g., Naval Research Laboratory, National Institutes of Health, National Bureau of Standards), do you believe that this assessment is either accurate or correct? Do you believe that the Federal in-house laboratories should be considered as candidates for designation as National laboratories? What would be the inherent advantages or disadvantages in using the existing Federal laboratory structure as a vehicle for creating National laboratories? Do you believe that it is axiomatic that a National laboratory can only exist within the context of a university relationship?
14. What should be the mix of applied versus basic research in a University/National laboratory? How would this mix compare with the current mix that obtains presently in your institution? How would you accommodate the change in program content? If the national oceanographic program requires a significant fraction of applied research, would this militate against your institution's acceptance of a University/National laboratory designation?
15. If your institution were not to be designated as a University or National laboratory, how would that affect it? Do you feel that the designation of a selected group of laboratories would effectively inhibit the growth of those laboratories which were not so anointed? How would you view this situation from the standpoint of the overall health of the national oceanographic effort?
16. What are your present growth plans for the next ten years with respect to your staff, your program, special facilities, buildings, and ships, assuming that you are not designated as a University/National laboratory? What capabilities do you anticipate that you will have by 1980 to conduct research and/or train future oceanographers? Comment on the present adequacy of your ability to train oceanographers. How

would this assessment change if your institution were to be designated as a University or National laboratory?

17. What do you see as the proper ultimate staff size, budget level, and physical plant size of your institution? When do you expect to achieve this status, and upon what do you base your estimate on terminal size? Would the designation of your institution as a University/National laboratory help or hinder your long-term plans?
18. Based on the experiences in Federal in-house laboratories, it is reasonable to anticipate that, if you were to be designated as one of the University/National laboratories, then various laboratories in the system might be assigned as lead laboratories or possibly might be given as exclusive franchise to conduct research in specific fields of oceanography (i.e., marine biology, geophysics, physical oceanography, etc.). How would you accept and adjust to such an arrangement, which might preclude your staff from working in certain fields of oceanography?
19. The recommendation concerning the establishment of estuarine and coastal zone research institutions states that the network of such institutions should be established in association with appropriate academic institutions. Do you feel that the applied aspects of coastal zone research are necessarily a proper area of research for an academic institution? Do you feel that it is appropriate for academic institutions to work closely with State and local governments to allow them to manage local resources? Would the establishment of such a network preclude your institution from partaking in work where it currently has significant interests and activities?
20. What do you consider to be an appropriate size and a critical size for an estuarine and coastal-zone research institution? What facilities would you foresee that such an institution would enjoy? The Commission refers to the term "network" to describe these institutions. How do you foresee the operation of a network? Would it require program coordination, facility coordination, common funding, and/or sponsorship by a single Federal agency?
21. What do you foresee as your institutional responsibility to the mapping and charting activities of the Federal government? How can these activities be made responsive to the needs of basic sciences? What mechanism should be established whereby the mapping and charting activities of the Federal government can be reviewed to insure both responsiveness to the needs of science and responsiveness to the intrinsic interest of various operational branches of the Federal government?
22. The Commission recommends that the major civil responsibility for providing institutional and facility support should be investigated in the new agency recommended by the Commission and that the National Science Foundation should be relieved of this responsibility, while the Office of Naval Research should continue to provide the kinds of support it has in the past. Other Federal agencies should provide limited institutional and facility support. How do you construe this recommendation in the context of the possible designation of your institution as a University/National laboratory?
23. In the text of the Commission's report, it recommends a target of 50 percent in-house Federal laboratory and 50 percent out-of-house as being a reasonable goal for basic research. It does, however, recognize that this ratio will be a function of agency needs as well as agency programs. Do you concur with this assessment as to the relative scale of Federal in-house research to non-Federal research? Essentially, do you believe that the funding support for Federal in-house basic research laboratories in the field of oceanography should be matched on a dollar-for-dollar basis with that of the non-Federal laboratories? If such a target were to be achieved, given the present national oceanographic

budget, how would that reduce or expand the relative fraction of the total funds available to your institution? The Commission recommends that the basic science effort of this Nation must be maintained and expanded to accomplish the program described in its report. It recommends an incremental increase of approximately 20 percent a year for operating and capital expenditures, which should be maintained until the current basic science funding base is increased by \$200,000,000 annually. If Congress were to agree to such a program, what capabilities would you anticipate that your institution would have, assuming that you were to be allocated a pro-rata amount of such an increase?

24. In the 1966 report of the President's Scientific Advisory Committee on the Effective Use of the Seas, the recommendation was made that all oceanographic fleets or vessels be regional fleets. The Commission did not concur with this view, although it anticipated that the University/National laboratories could be expected to provide ship facilities from many scientists from nonship-operating institutions. If you were to be designated as a University/National laboratory, how would you handle the ship scheduling problem? How would you charge for the use of ship time? How would these procedures differ from the procedures that you currently follow? Would the time and services of your ships be more or less generally available to outside users?

RECIPIENTS OF QUESTIONNAIRE A

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| Institute of Marine Sciences University of Alaska | Lamont-Doherty Geological Observatory Columbia University |
| Scripps Institution of Oceanography University of California | Institute of Marine and Atmospheric Sciences University of Miami |
| Coastal Engineering Research Center Department of the Army Washington, D. C. | Department of Oceanography Oregon State University |
| Marine Laboratory Duke University | Graduate School of Oceanography University of Rhode Island |
| Gulf Universities Research Corporation Houston, Texas | College of Geosciences Texas A and M University |
| Hawaii Institute of Geophysics University of Hawaii | Department of Oceanography University of Washington |
| Department of Oceanography The Johns Hopkins University | Woods Hole Oceanographic Institution Woods Hole, Massachusetts |

QUESTIONNAIRE B

1. What do you see as the role, responsibilities, mission, and operational problems of a National laboratory?
2. How would the present method of operation of your institution be changed if you were not designated as a National laboratory?

3. What do you see as the obligation of the Federal Government to a National laboratory?
4. Should the Federal Government block-fund one or more of the following aspects of National laboratory costs: facilities, overhead personnel, new buildings, individual programs, or specific investigators?
5. What process of review exists for the evaluation, and coordination of your operations?
6. What do you believe to be the appropriate size of a National laboratory?
7. What requirements should be satisfied before an institution can qualify for designation as a National laboratory?
8. What process is followed in order to make the unique facilities of your institution available to nonresident scientists?
9. Do you have user groups or external review panels which consider the technical merits of the programs of outside investigators, who propose to use the facilities of your institution?
10. When outside user groups wish to use your facilities, how are they charged? Specifically, do they pay labor, facility rental charges, and/or a pro rata share of institution overhead costs?
11. When your institution determines that there is a need for new or expanded facilities, what process is used to provide funds and what is the financial route that must be followed. Are you required to show that the facilities so desired are both unique and singularly appropriate to your institution?
12. Do you feel that the existence of National laboratories provide particular advantages to the American academic community? If so, what are these?
13. How might the operation of our National laboratories be altered to optimize utilization of large and expensive facilities?
14. If your institution has either a Board of Governors or a Board of Visitors, how are the members of these Boards selected? What groups are represented and how are the national and public interests protected?
15. Is there an optimum corporate structure of management agencies for a National laboratory? Discuss the pros and cons of operating a National laboratory as:
 - a. A Federal Civil Service Laboratory
 - b. A Federal Contract Research Center
 - c. A University-affiliated laboratory
 - d. A nonprofit corporation
 - e. A laboratory managed by a commercial corporation under contract to a National agency.

RECIPIENTS OF QUESTIONNAIRE B

This Questionnaire was transmitted to the Directors of selected National laboratories.

Argonne National Laboratory
Argonne, Illinois

National Magnet Laboratory
Cambridge, Massachusetts

Brookhaven National Laboratory
Upton, New York

National Radio Astronomy Observatory
Green Bank, West Virginia

Kitt Peak National Laboratory
Tucson, Arizona

Oak Ridge National Laboratory
Oak Ridge, Tennessee

APPENDIX B

INTERVIEWS

The following persons were interviewed by members of the Task Force on Marine Laboratories:

Mr. Bruce T. Lundin
Associate Administrator for Advanced Research and Technology
National Aeronautics and Space Administration

Mr. Joseph M. Caldwell
Technical Director
Coastal Engineering Research Center
Department of the Army

Dr. William A. Nierenberg, Director
Scripps Institution of Oceanography
University of California, San Diego

Dr. Paul M. Fye, Director
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

APPENDIX C

MEMBERSHIP

TASK FORCE ON MARINE LABORATORIES

Dr. Alan Berman (Chairman)
Director of Research
Naval Research Laboratory

Dr. James S. Coleman
Technical Advisor
Atomic Energy Commission

Mr. Harold L. Goodwin
Planning Officer
Office of Sea Grant Programs
National Science Foundation

Mr. John L. S. Hickey
Sanitary Engineering Director
Public Health Service
Department of Health, Education and
Welfare

Dr. Merton C. Ingham
Director of Oceanography
Oceanographic Unit
U.S. Coast Guard

Miss Mary K. Johrde
Program Director, Oceanography Section
Division of Environmental Sciences
National Science Foundation

Mr. Arnold B. Joseph
Marine Science Council
Executive Office of the President

Captain Justin E. Langille, III, USN
Deputy Director of Navy Laboratories
Department of the Navy

Mr. Morton Rubin
Deputy Chief, Plans and Requirements
Division
Environmental Science Services
Administration
Department of Commerce

Mr. John F. Ryan
Office of Facilities
National Aeronautics and Space
Administration

Dr. Albert I. Schindler, Head
Metal Physics Branch
Metallurgy Division
Naval Research Laboratory

Dr. Roland F. Smith
Assistant Director
Office of Marine Resources
Bureau of Commercial Fisheries
Department of the Interior

Dr. I. Eugene Wallen, Head
Office of Limnology and
Oceanography
Smithsonian Institution

Mr. William D. Garrett
(Executive Secretary)
Ocean Sciences Division
Naval Research Laboratory

Additional assistance was provided to the Committee by:

Mr. Robert B. Abel
National Science Foundation

Mr. Max C. McLean
ESSA, Department of Commerce

Dr. Dail W. Brown
Smithsonian Institution

Mr. Herbert B. Quinn
National Aeronautics and Space
Administration

Mr. Robert N. Culnan
ESSA, Department of Commerce

Mr. Glenn Schleede
Bureau of the Budget

Dr. David T. Goldman
Bureau of the Budget

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